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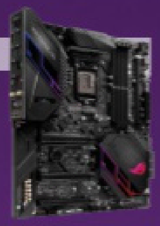

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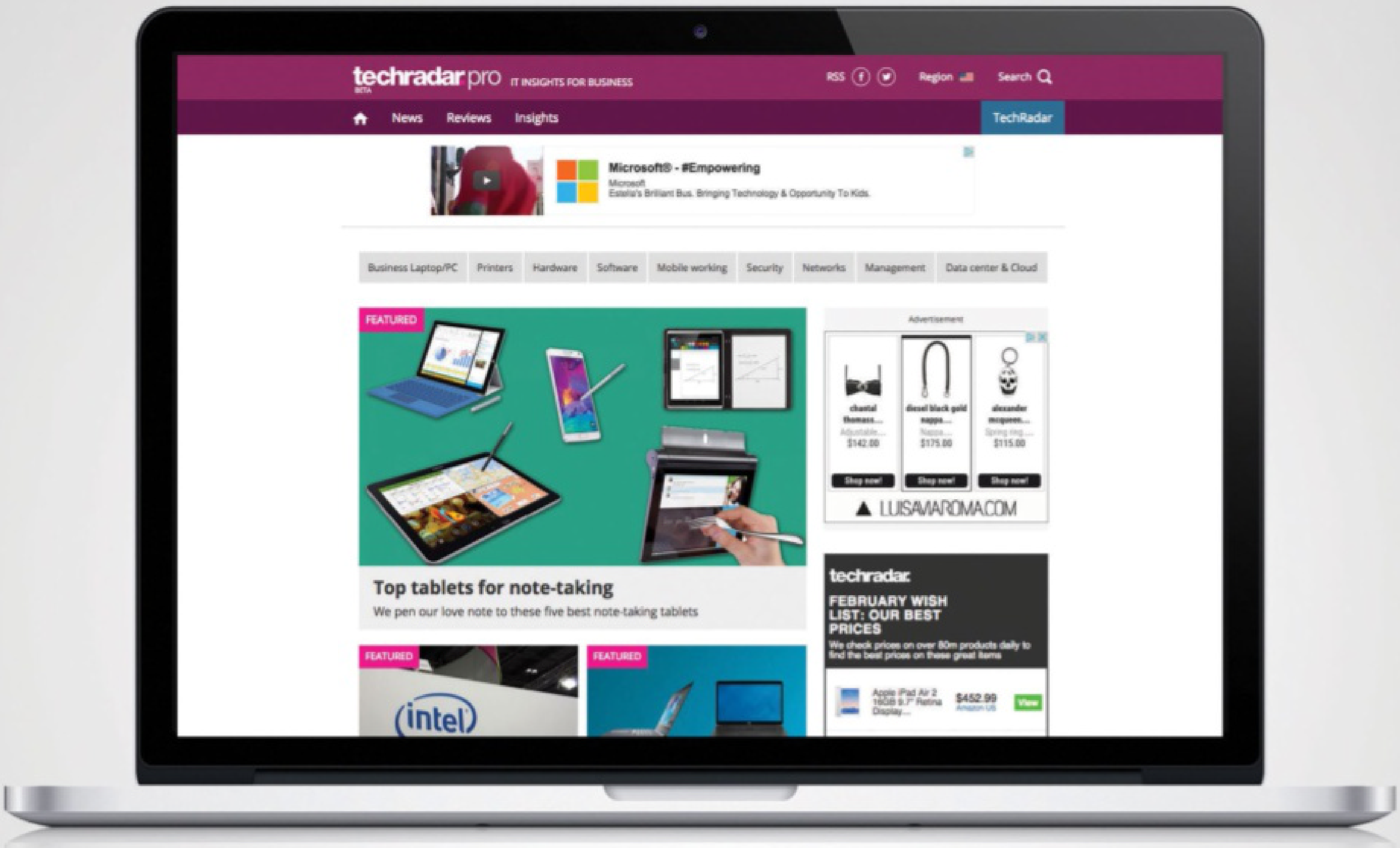
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Alan
Dexter

IT'S THE STUFF OF DREAMS, BUT IT CAUSED A FEW NIGHTMARES...

AFTER A YEAR'S HIATUS, the Dream Machine returns. And what a return. Boasting not one, but two systems, both water-cooled, and fitted out with the latest and greatest hardware, it has drawn gasps even before the overall component price is revealed—at which point the gasps turn to shock, but that's the nature of going above and beyond the norm. The Dream Machine is not reasonable, it's excessive.

This year, the Dream Machine hasn't been without its issues, and while you could say that pretty much every year, sorting out two systems comes with its own special level of stress, and not just from trying to balance power between two very different form factors. Throw in a healthy amount of water cooling, the added fun of two separate power supplies, and trying to manage airflow, and you've got plenty to juggle way before you reach the joys of getting a blank screen on your first boot.

Still, once we'd battled through such an issue, stared in disbelief at the ridiculous pile of component boxes we'd amassed, and calmed ourselves over the potential of leaks in the loop, we could start to enjoy the performance. When you've got a total of 40 cores and 80 threads to play with, finding benchmarks and tests that can even begin to challenge this system is one of the biggest challenges of all.

One thing that's hard to get across on the cover is the sheer size of the thing. The Obsidian 1000D is a humongous case, and even those who have seen the likes of the Cosmos II up close won't be prepared for just how big this is. The fact that it has room to house two complete systems is some indication of its size, but you've got to see it (and, if you're feeling fit, try to lift it) to get your head around how monstrous it is.

The Dream Machine may be a big story—OK, it's huge—but it isn't the only thing in this issue. We take a long hard look at the current state of gaming motherboards, and investigate what the extra premium nets you. We also ask a question that most of us have wondered about for a long time: Do you actually need a soundcard? We show you how to get Windows 10 running on the Raspberry Pi, take a look at Nvidia's latest Turing-powered graphics card, and check out one of the most powerful laptops we've ever had in the lab.

This issue, we also welcome a new member to the team, as Christian Guyton joins us as a staff writer. Christian has turned his hand to a range of freelance gigs, but is at heart an eager PC gamer. This month, he has penned his first "Build It," which just so happens to be his test machine going forward. Built around the Nvidia GeForce RTX 2060, the final machine is a great snapshot of the current state of mainstream PC hardware, and a neat little build he has managed, too. Please join me in welcoming him!

Alan Dexter is Maximum PC's *executive editor and a punisher of hardware. He's been a tech journalist for over 20 years, and has no problem upsetting the PC industry as a whole.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Google Goes Games

New streaming cloud service changes everything

GOOGLE IS TO launch a game streaming service called Stadia, already dubbed "Netflix for games." It promises to deliver more gaming power than Microsoft's and Sony's consoles combined, with 4K at 60fps possible on even the most modest of hardware. Games will run in Chrome browsers, Pixel devices, and TVs with Chromecast dongles. Other than this, it is platform independent; you can play any game on any device with a healthy Internet connection. According to Google, Stadia addresses all the limitations of traditional gaming systems, and brings "a game platform for everyone."

There will be just one bit of hardware, an optional controller, which includes buttons to activate Google Assistant, and to stream your efforts to YouTube. It will communicate directly to the Stadia game servers via your Wi-Fi to reduce latency.

Multiplayer games can be huge, with thousands of players, and offer real-time world-persistent events. Stadia can also cope with multiple split-screens without graphical degradation.

The games industry is worth $140–180 billion a year, and is the world's biggest entertainment industry. Google has aimed Stadia right at its heart. The mere announcement of Google's plans was enough to wipe $3 billion from the shares of Sony and Nintendo in Japan.

The subscription model can be hugely lucrative; the music, television, and film markets have been transformed by this marketing model. Stadia goes further: Not only do you not own the game, you don't even need the hardware to run it.

Google needs the big titles, the top franchises, and decent exclusive content to reel in players. It accompanied its announcement with images from Ubisoft's *Assassin's Creed: Odyssey,* so presumably that's in the bag. It also has *Doom Eternal* in the pipeline. Google isn't short of money, so support shouldn't be hard to ensure. It has formed Stadia Games and Entertainment, to oversee game development, and is working with all the major game publishers, although rumor has it that EA is not playing ball yet.

Google tested Stadia last year, aiming for 1080p at 60fps, which chews through 20–25Mb/s. The launch target is full 4K, which requires about 30Mb/s. The lowest resolution will be 720p. Google has some "very clever technology" to smooth over any connection droppages, and it boasts that Stadia provides 10 teraflops of power for a game session, compared to 4.2 from a PS4 Pro, and 6.0 on an Xbox One X.

One smart feature is State Share, where a moment in a game can be captured, then shared as a link. So, you can send your finest kill to a friend, who can use Stadia to reproduce it in the game—not a video clip, but as the actual moment fully recreated in the game. Crowd Play enables players to form a queue to jump into a game. Another "fun" feature is Style Transfer, which runs the game graphics through an AI system running art styles filters. It looks amazing, although pointless.

Stadia could be yours by the end of the year, but we have no news on the price, or even if it will be a flat subscription, a fee per game, or per session, or a mix of methods. It won't be for everyone, especially hardcore gamers; however "clever" the tech, it won't be as responsive as a high-power gaming rig running a game locally. And both Sony and Microsoft have at least another generation of consoles to come.

Stadia might not kill the traditional games hardware market just yet, but it is going to give the industry a good shake. Especially for the more casual gamer, who doesn't want to invest in the hardware required to get a game running properly, and has no interest in tweaking the experience. The lure of high-power gaming on low-power machines, plus complete cross-platform compatibility, is tantalizing. No boxes, no expensive graphics cards, no downloads—just jump straight into the high-res game of your choice. Ubisoft's CEO, Yves Guillemot, said to think of it as "complementary" to PCs and consoles.

Games are going to the cloud, and Google isn't alone: Apple, Microsoft, Amazon, and Tencent are all developing similar gaming services. Like it or not, this is where the market is heading. **–CL**

> No boxes, no expensive graphics cards, no downloads.

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FACEBOOK TO LAUNCH ITS OWN CURRENCY

Now it wants to handle your money, too

HOW DO YOU FEEL about trusting Facebook with your money? It's developing its own blockchain-based cryptocurrency. There has been no official announcement as yet, although it has been working with distributed ledger technology for a while. Facebook has been on a hiring spree, too, and the DTL development team is headed by the former president of PayPal.

It looks as if the initial plan is for people to be able to send money to their WhatsApp contacts without any agent in between, just Facebook, which would take a small slice. Sending money "home" to another country is a huge business, which can attract large fees. Eventually, the new system will be used to sell content through Facebook, from micro-payments for apps upward, turning Facebook into a marketplace.

The company has already (reportedly) been talking to cryptocurrency exchanges about dealing in Facecoin (OK, that is an unlikely name for it). The cryptocurrency will not be the typical version, with massive price swings, but backed by hard cash and stable. To do this, you need to deposit some real money in a bank; Facebook can probably manage this.

Facebook needs another way to make money other than selling ads, and has been struggling to make money from WhatsApp. When Facebook does something, it tends to do it big, and this is potentially huge. Analysts at Barclay's have estimated that it could net Facebook $3–19 billion a year. Shareholders are already pleased.

Facebook has had its share of scandals, and Zuckerburg's recent pronouncements on privacy look ironic given its troubles with misused personal data. Moving into the financial world will bring closer scrutiny, and possibly regulation, but also rich pickings; in China, WeChat Pay currently transfers $10 trillion a year. **–CL**

ATARI VCS DELAYED, BUT UPGRADED

PART RETRO, PART MODERN: THE NEW ATARI

LOOKING FORWARD to the new Atari VCS console? Then you will have to wait a little longer for this slice of nostalgia, as the launch has been put back (again) until the end of the year at the earliest. The delay is to allow for a hardware upgrade. The VCS is to get a Ryzen chip (we aren't sure which yet), along with Vega-based graphics. This will give it distinctly un-retro abilities, such as 4K at 60fps. It's an odd machine: part retro gaming console, part modern streaming content platform (it supports DRM video, so Netflix and HBO are possibilities). Its Linux "Sandbox" system can be customized, and it has the power to run modern games. The project got off the ground thanks to crowdfunding, and has gathered an enthusiastic following. It's currently priced at $329 with controllers. **–CL**

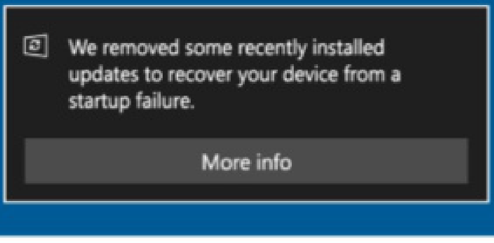
WINDOWS TO REMOVE BROKEN UPDATES

New feature can automatically solve problems

THE NEXT UPDATE of Windows 10, the April 2019 Update, is nearly upon us, and among the slew of new features is the ability to uninstall updates if there are serious problems. This follows the troublesome October 2018 Update, which caused all sorts of problems, including the possible deletion of files from My Documents. The initial version was withdrawn, patched, and withdrawn again after new bugs emerged. The update was three months late.

According to the support documents for the latest update build, if Windows can't start properly, due to corrupt files, driver errors, errant Registry keys, or such, and a recent update is the suspect, Windows will remove it, and try again. If this works, it will block the update for 30 days, to give a chance for it to be fixed, before updating again.

Windows Update has a poor reputation, and adding a system to fix things that shouldn't be broken in the first place is hardly laudable, but it is an improvement. **–CL**



We removed some recently installed updates to recover your device from a startup failure.

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

XBOX DITCHES DISC
The new Xbox One S, due this year, will have no disc drive, and will be the cheapest yet.

PS5 BACKWARDLY COMPATIBLE?
It's not official yet, but the patents have been filed—you might not have to abandon all your games.

FIREFOX STOPS AUTOPLAY
Version 66 will automatically silence those annoying auto-playing videos. Thank you.

TRAGEDIES

GOODBYE GOOGLE+
From 100 million users to a wasteland, Google finally kills its attempt at social media.

KOREAN SPIES
42 motel rooms in Korea were found to have had webcams in them for months, available online by subscription.

MAN STEALS $122M
A Lithuanian man scammed Google and Facebook with fake invoices, an old-school takedown of two tech giants.

Intel to Build Graphics Cards

IT LOOKS AS IF WE'RE going to get a third major player in the graphics card market as Intel announces that it's getting ready to launch its own discrete graphics card in 2020. Intel says it will be branded Xe, and include mid-range, "enthusiast," and data center AI cards. The GPUs will be built around the Gen11 integrated graphics architecture.

The Gen11 iGPU is set to appear first in the 10nm Ice Lake processors (which use the new Sunny Cove core architecture). It has up to 64 execution units, an increase from the 24 on the Gen9, which give it 2.67 times the computational power. This will give Intel's processors some pretty tasty graphics without outside help, on a par with the Radeon Vega 8 in AMD's APUs.

Putting together a brand-new graphics card design takes years, and Intel has been quietly gathering the talent required. Last year, it poached Raja Koduri from AMD, who was behind reorganizing AMD's graphics division. Intel's visual computing group is now said to number 4,500 people, so its move into the market isn't exactly a surprise.

The use of GPUs as computational devices has exploded in the last few years. Ten years ago, no supercomputer used them; now they provide most of the processing power in the top machines, and are all over data centers, the cloud, and blockchains. It was an obvious target for Intel—using GPUs means machines aren't using Intel's profitable server chips. **–CL**

intel
Intel® Graphics™ 1°

A render of Intel's new graphics card: smooth, minimalist, and not covered in RGB lights. All pure speculation, though, as we won't see the finished hardware until next year.

Ray Tracing on the GTX

Nvidia is to include ray-tracing support in its latest drivers for the GTX 10x0 and 16x0 cards. Why? Well, it does show what you're missing, which might prompt you to upgrade to a card that can run RT in its full glory. It may also help development. Few have full-fat RTX cards, but there are plenty of GTX ones about. You can also set the levels of RT right down, which may look better, without hitting performance too much; this might get developers moving to add support. What you won't get is DLSS, Deep Learning SuperSampling—that really does need those Tensor cores, which is a pity, as it's good at improving ray-tracing performance. **–CL**

DX12 Gets VRS

Microsoft is going to add Variable Rate Shading to DirectX 12. Why? Because as game resolutions climb toward 4K, it takes a lot of power to render a scene, and putting that power where it's needed can make all the difference. Currently, the shading rate is fixed across all pixels in a frame. Using a variable rate means areas of low detail don't have to get the same attention—developers can pick a suitable shading rate for each element. Tests indicated about a 20 percent improvement in frame rates, although results vary depending on the game, and how much work the developers put into specifying the shading rates. Nvidia has hardware support for VRS, as will Intel's forthcoming Gen11 graphics. **–CL**

USB 3.2 FINALLY READY, AND USB 4.0 TO FOLLOW

One socket to unite them

THE NON-PROFIT GROUP in charge of USB specifications, the USB Implementers Forum, has announced the initial specs for USB 4.0, and that USB 3.2 is finally ready. And it has done a spot of name changing in the process. Just as USB 3.0 morphed into USB 3.1 Gen1, USB 3.2 will absorb the previous USB 3.0 and USB 3.1 specifications. So USB 3.1 Gen 1 is now to be known as USB 3.2 Gen 1, while USB 3.1 Gen 2 becomes USB 3.2 Gen 2. On top of these is USB Gen 2x2, the new part. As the name indicates, this gives double the data rate, reaching a theoretical maximum of 20Gb/s. This is achieved by doubling the physical data channels; it's essentially two USB 3.1 Gen 1 10Gb/s connections in one, made possible by switching over to the USB-C connector, which has more data lines. This was designed so you could plug devices in either orientation, but as the wires are there, why not use them?

Changing the names is confusing. The USB-IF has suggested using different marketing terms, such as SuperSpeed USB 10Gb/s for the old USB 3.1 Gen 2, and SuperSpeed USB 20Gb/s for the new Gen 2x2, which is a little better. The standard was "launched" in September 2017, but we've seen nothing yet—the USB-IF claims controllers will be ready this year.

After this we have USB 4.0, the details of which have yet to be finalized, so is still some time away. It is, roughly, a combination of USB 3.2 and Thunderbolt 3 (owned by Intel), wrapped in the USB-C connector. It will be compatible with both the hosts and devices of both protocols. It doubles the speed again, to a maximum of 40Gb/s, the sort of bandwidth that can run 4K screens. It can also deliver useful amounts of power. The exact specifications of USB 4.0 will be finalized later in the year. One of the big strengths of USB is that it's cheap to implement; Thunderbolt 3 isn't, so we might see some compromises in the final details. **–CL**

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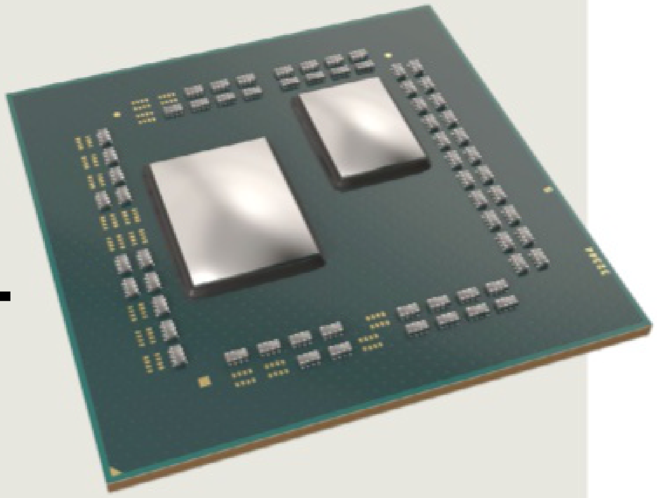
Jarred Walton

TECH TALK

AMD Ryzen: Third Gen's the Charm

IT'S EASY TO FORGET just how bad the processor landscape was only a few years ago. Before March 2017, the best mainstream CPUs on offer were mere four-core/eight-thread Intel parts.



Ryzen's third outing will see the use of a dual "chiplet" design.

AMD was limping along with a flawed Bulldozer-derived architecture and FX-series processors, the best of which were only about equal to Intel's Core i5 processors—but with two to three times the power use under load. In short, AMD CPUs were struggling and Intel CPUs were coasting.

There were faster options, specifically Intel's HEDT parts, such as the i7-6800K for LGA2011-v3, but pricing could get just as extreme as the model names. Ryzen changed all that. AMD's individual cores still couldn't quite match Intel, but with twice the cores/threads for roughly the same price, enthusiasts suddenly had an alternative.

The result was a frenzy of CPU releases in 2017 and 2018. Now, heading into the third year of Ryzen, AMD is prepping its Zen 2 architecture for release. Unlike the previous minor update of Zen+ (tweaks to the fabrication process, reduced latency, and a few other modest updates), Zen 2 could deliver a far larger performance jump. AMD demoed one such chip in December, showing an unnamed Ryzen matching the performance of the Core i9-9900K in Cinebench. The hook is that the Ryzen chip is rumored to be a mid-range "Ryzen 5," which if true, could really put pressure on Intel.

AMD has two major changes coming with Zen 2. The big news is it will be the first 7nm x86 processor, potentially leapfrogging Intel and its 10nm Cannon Lake difficulties. Intel is talking more about its Ice Lake processors now, originally slated to be its second generation of 10nm CPUs, with hardly a word about Cannon Lake. Even if AMD's 7nm lithography ends up being closer to Intel's 10nm lithography (it's actually less dense, despite the naming), when was the last time AMD had an advantage in process technology? Answer: never.

> When was the last time AMD had an advantage in process technology? Answer: never.

The process shrink opens the door for greater refinements in the CPU architecture, but AMD isn't saying much just yet. What we do know is that there's a separate on-package chip manufactured using 14nm technology. This "chiplet" will handle IO functions, including PCIe lanes (PCIe 4.0 is available), the memory controller, USB ports, and AMD's Infinity Fabric—though the CPU would also need an Infinity Fabric link to talk to the IO chip.

AMD CEO Lisa Su also commented on the fact that there's room on the package for a third chip, likely a second CPU chiplet, suggesting the design can go from eight-core/16-thread to 16-core/32-thread for higher performance parts. Alternatively, that space could be used for a GPU or even an HBM2 stack. In short, the chiplet approach has many potential advantages for AMD.

One thing that isn't changing is the socket. Existing 300 and 400-series AM4 motherboards should be able to run the Ryzen 3000 parts with an appropriate BIOS update. It's even possible that some boards will offer PCIe 4.0 support for the first PCIe slot. Whether that will really matter remains to be seen—GPUs don't generally run much faster on PCIe 3.0 compared to 2.0, unless you're using multiple GPUs. AMD will also have 500-series chipset boards, which will be built from the ground up to support PCIe 4.0 and perhaps additional new features.

One of the big impediments to Ryzen performance with the current design has been the dual CCX (core complex) layout, where L3 cache accesses to a different CCX can be significantly slower. Games, in particular, seem to dislike this arrangement, and AMD is likely working to address this for mainstream models. There have also been leaks suggesting we could see clock speeds of up to 4.8GHz, basically matching Intel's 9th Gen desktop parts.

The third generation of Ryzen processors is expected around Computex in June, potentially several months before Intel's Ice Lake processors. That's not far off, and I'm eager to see what AMD brings to the party with Zen 2. If it's anything like the past two years of Ryzen, we could see even more competition for the CPU throne, and perhaps even a new champion.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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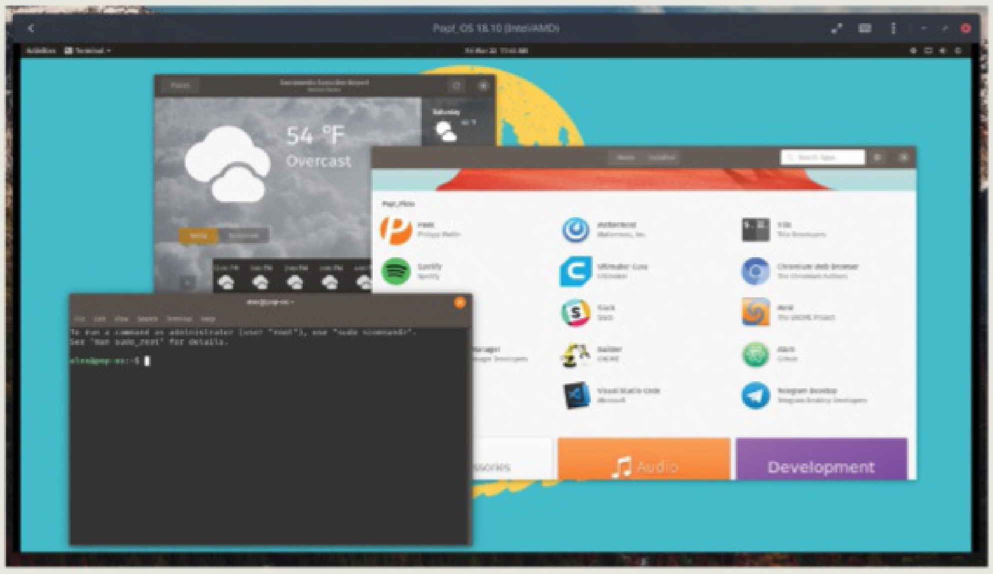
Alex Campbell

OPEN SOURCE

Boxes: A Simpler VM Manager for the Masses

VIRTUAL MACHINE ADMINISTRATION can be complex to manage, but if all you want is to run a Debian instance on your Fedora box for a few minutes, VirtualBox can feel like overkill. GNOME Boxes lets you get to what you're looking for: A simple way to fire up a VM without any muss or fuss.



Pop! OS running in GNOME Boxes on a Manjaro host.

Dual-booting is a pain. I've begun booting into my Ubuntu installation on my desktop instead of Windows to get work done. However, in order to try out different Linux boxes, it can be a hassle to fire up VirtualBox, grab an ISO, and allocate the resources I think the virtual machine might need. There has to be a better way. And there is.

I looked around and discovered GNOME Boxes, a virtualization application for the GNOME desktop. The coolest thing about it is the sheer simplicity.

From the first run, you're greeted with a simplistic interface. When you want to add a new VM, it presents you with a basic list of some great Linux OSes: Red Hat Enterprise Linux, Fedora 29, Ubuntu 18.10, openSUSE Leap, and Debian 9. However, if you click "Show more," GNOME Boxes lists even more OSes, such as Pop! OS or NetBSD. If you choose from the list, Boxes downloads the ISO and starts the installation for you. In VirtualBox, this would require locating the ISO, mounting it, and doing the boot-up rigmarole. I feel like Boxes makes this all easy and intuitive.

If you're looking to try out a Linux distro that isn't in the list (such as Gentoo or Arch), you can always point Boxes at a downloaded ISO as well.

This is because Boxes is basically a graphical application for the Linux QEMU hypervisor. (That's a fancy way of saying it's a GUI for the standard Linux virtual machine host software.)

There's a lot of reasons to run a VM. If you're learning how to administer a server, for instance, running a server in a VM that you can trash means you don't have to muck up your own installation. It also enables you to try other OSes without the need to constantly reinstall the OS and configure boot options. (Who wants to triple or quadruple-boot?)

The way I look at it, the biggest non-development or IT reason for using a VM is data isolation. Say you have specific requirements (such as work for a client) that are sensitive. Instead of entrusting that data to your own installation, you can keep a sanitized work environment in a VM. You can also back up that VM instance to a cloud storage service or server in case anything goes pear-shaped. (If you do, use full-disk encryption in the VM instance and/or encrypt the image before sending it to the cloud.)

The downsides are the same as in VirtualBox: You won't have access to all the hardware on the host, most notably the display driver, so don't count on being able to play games or access the video card for GPU tasks. For that, use bare metal and Docker containers.

Boxes also serves as a remote administration manager. It can handle remote connections to Windows boxes through RDP, or Linux desktops through VNC. It can also handle SSH connections, though I prefer to simply run SSH through a terminal anyway.

If you are a GNOME user, I highly recommend grabbing GNOME Boxes from the GNOME Software (or distribution-specific) app store. Give it a whirl, and try another flavor of Linux. If you don't like it, you will have wasted almost no time to configuration and data migration, and you can get the disk space back as soon as you delete the VM.

Alex Campbell is a Linux geek who enjoys learning about computer security.

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THE LIST

VR HEADSETS THAT DIDN'T QUITE MAKE IT

8

PIMAX 5K PLUS

Fragile, expensive, and demanding a very powerful rig to function, Pimax's attempt at high-end VR tech met little success.

7

OCULUS GO

Despite being a frontrunner in the field of modern VR with its Rift headset, Oculus failed to impress with its later offerings.

6

VIRTUALITY 1000

An early British attempt at VR, this headset came with a wide array of peripherals, from plastic rifles to aircraft yokes.

5

VIRTUAL BOY

This list would be incomplete without Nintendo's infamous foray into headset gaming. Anyone for red-tinted Mario tennis?

4

GOOGLE CARDBOARD

Not as much a failure as others, Google's ultra-cheap offering nonetheless failed to leave a lasting impression.

3

LENOVO EXPLORER

The most recent entry on this list, the 2017 Explorer was sadly too little too late from Lenovo.

2

HELMET VISION

A bulky, expensive, independent headset that tried and failed to counteract Oculus and Vive.

1

VFX1 HEADGEAR

This forgotten headset came with a weird, hockey-puck-shaped controller and a $700 price point.

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HEAD TO HEAD

BY **CHRISTIAN GUYTON**

Apex Legends vs. Fortnite vs. PlayerUnknown's Battlegrounds

Battle royale games are becoming something of a plague in gaming right now. We mean that in a good way; there are loads to choose from, and some of them are an absolute blast. Everything from shooters to MOBAs to *Tetris* has taken a shot at the battle royale crown, but there is only a handful that makes it to the big league. With that in mind, this month we're weighing up the three heaviest hitters in the genre: originator *PlayerUnknown's Battlegrounds*, free-to-play titan *Fortnite*, and plucky newcomer *Apex Legends*.

ROUND 1

Gameplay

This is a hard one to judge—how enjoyable each game is will always be a subjective and divisive topic, and each has its merits. *PUBG* was the first to popularize the genre, and offers both first and third-person viewpoints. *PUBG* and *Fortnite* place 100 players into each match, while *Apex* runs just 60. *PUBG* wins points for having five maps against the others' one, but map design in *Apex* and *Fortnite* is superior.

Fortnite and *PUBG* offer squad-based and solo experiences, while *Apex* forces players into trios, giving an advantage to players grouping up with friends. This could be a deal-breaker, were it not for *Apex's* staggeringly good "ping" system, which enables fast and effective non-verbal communication. Anything can be pinged for your teammates, making good cohesion possible even for match-made squads.

Fortnite has the most interesting mechanic; the ability to rapidly build structures to provide cover, elevation, or new pathways. Ultimately, though, these are shooters, so the final decision comes down to gunplay. Here, *Apex* is king; Respawn's pedigree in designing the excellent *Titanfall 2* hasn't let it down, and every weapon handles with punchy, satisfying weight.

Winner: Apex Legends

ROUND 2

Graphics

Let's get this out of the way: It's not *PUBG*. Sorry *PlayerUnknown*, but a smaller development team means fewer hands to work on pretty textures and animations. *PUBG* looks fine, but it's unexciting. Epic Games and Respawn Entertainment are giants in comparison, but have gone for wildly differing styles, so it's a tricky decision.

Fortnite is a brightly colored cartoonish smorgasbord of characterful animation and design that looks great even on older rigs. The environments are vibrant and varied, and every new seasonal event brings a bombastic array of new cosmetic items. The graphics are relatively basic, though, the art style meaning that some textures look flat and bland.

Apex Legends plumps for a more realistic visual style, pitching players into a military installation on a lush jungle island. Water and particle effects are more sophisticated, and textures look fantastic on more powerful machines; particular care has been lavished on the guns, all of which look sexy as hell in their steel and chrome. The character animations are full of life, too, bringing a touch of personality to the battle royale genre. It's tough, but this has to go to *Apex*.

Winner: Apex Legends

ROUND 3

Performance

A well-made game should be playable on just about any mid to top-range PC, and battle royales are no exception. With a huge amount going on in any given match, all three are vulnerable to network dropouts, and need to process lots of simultaneous events. We look, then, to optimization.

PUBG suffers again from its smaller dev team, meaning that the game isn't well optimized for running on older or cheaper machines. Texture pop-in, visual glitches, and frame rate stutters during busy gunfights are all common. Indeed, the game was plagued early on by players running on minimal settings able to see through foliage that was concealing their high-graphics opponents. *Apex Legends* doesn't fare much better; while it looks great, it demands a lot from the hardware, and isn't going to hit high frame rates without a seriously powerful build.

Fortnite, on the other hand, could run at 60fps on a tub of ice cream. The simplified graphical style and minimal particle effects might mean that it isn't as pretty as *Apex*, but it runs smoothly on low-spec rigs with little trouble. Frame rates are rarely an issue, and the basic textures significantly reduce pop-in on older GPUs. A clear winner.

Winner: Fortnite

ROUND 4

Value

PUBG is really taking a beating in this one. At least it has Steam's Game of the Year 2018 award to console it. The older battle royale will set you back $30 on Steam, while *Fortnite* and *Apex Legends* are both free to play from the Epic Store and Origin respectively. All three games have microtransaction support and premium currencies for cosmetics (because of course they do), but only *PUBG* is still sticking doggedly to the ancient loot box key system.

Following the breakout gambling controversy, *Fortnite* removed loot boxes, now following a season-based unlock system. Season passes aren't too steep, and provide access to an additional progression track, making the game somewhat subscription-based for long-term players. Items can still be purchased with "V-bucks," but many are wallet-cripplingly expensive.

Apex follows the loot box system, with Apex Packs earned by leveling up or purchasable from the store. Items can also be bought using in-game or premium currency, or crafted using components from loot boxes. Just before going to press, *Apex* introduced its own seasons with Battle Pass, which mimics *Fortnite*'s offering. Still, we feel *Apex* has the edge.

Winner: Apex Legends

ROUND 5

Longevity

As the new kid on the block, *Apex* is exempt from this category. It's hard to judge whether a new game will stand the test of time, even if it is good. EA's involvement is enough to make anyone nervous. That leaves *PUBG* and *Fortnite* to battle it out.

PUBG is the older of the two, *Fortnite's* battle royale mode cobbled together from the original co-op survival concept (still hanging around as *Fortnite: Save The World). PUBG* arguably has the advantage of a more focused team of creators; Epic Games is striking out in new directions with the money from *Fortnite's* success, while PUBG Corp lives up to its namesake by focusing on delivering the best possible version of the game.

Fortnite has become almost omnipresent, though. Every gamer, journalist, and suburban mom knows the name, and Epic has ported it to consoles with significantly more success than its competitor. While both *Fortnite* and *PUBG* now have mobile offerings, *Fortnite* is currently the only game to make it to Nintendo Switch. A gander at Twitch delivers the killing blow: Even after a brief lull following *Apex's* release, *Fortnite* has surged back to the top spot.

Winner: Fortnite

And the Winner Is…

This was a close call—well, a close call between *Fortnite* and *Apex Legends; PUBG* is beginning to show its age. *Fortnite* has long since surpassed it, catapulting Epic Games to unforeseen heights.

It'll be hard to unseat the king, but *Apex* is gunning for the throne, with superior weapon handling, graphical detail, and team-oriented gameplay. Respawn is a skilled team, and it shows. *Apex* just feels tight in a way that *Fortnite* doesn't; every weapon carefully tooled, every inch of the map honed to maximize blood-pumping combat engagements.

Titanfall's breakneck parkour might be absent, but movement in *Apex* is still a joy; hooking on to a zipline and gunning down an enemy as you speed overhead releases a burst of dopamine. *Fortnite's* architectural mechanics are novel, but can cause matches to devolve into tower-building snipe-fests.

At a fundamental level, *Apex* is simply better designed. But as in every head-to-head, only time will tell which game will last. ⏻

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Text Size Troubles
> Silent Sound
> Mystery Slowdowns

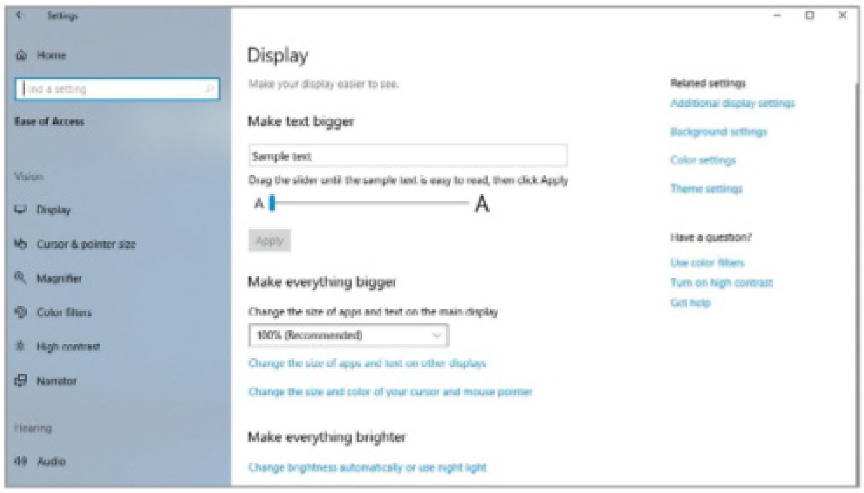
Windows 10 Font Sizes

Hi Doc, I've been lucky to have you answer some of my questions in the past, so I'm pressing my luck and asking another one. After upgrading to a new, much more powerful PC, I also purchased a 32-inch LG 32UD59-B monitor with a 4K native resolution. Windows 10 detected the display properly, set it to 3840x2160, and configured the recommended 150 percent scale, at which almost all the on-screen elements are fine. Unfortunately, some of the fonts (such as icon text fonts) are way too small.

In older versions of Windows 10 (before the Creators Update, I believe), you could go into the settings and change the icon text size without affecting anything else. But in the current version of Windows 10, Microsoft took that away.

In searching for a text sizing utility, I found several potential candidates, but I'm afraid to use them for fear that they might be loaded with malware. Can you recommend a clean app that allows the various text sizes to be changed independent of the display's overall scale?

–Gerald Exstein


Settings
Home
Find a setting
Ease of Access
Vision
Display
Cursor & pointer size
Magnifier
Color filters
High contrast
Narrator
Hearing
Audio
Display
Make your display easier to see.
Make text bigger
Sample text
Drag the slider until the sample text is easy to read, then click Apply
A
A
Apply
Make everything bigger
Change the size of apps and text on the main display
100% (Recommended)
Change the size of apps and text on other displays
Change the size and color of your cursor and mouse pointer
Make everything brighter
Change brightness automatically or use night light
Related settings
Additional display settings
Background settings
Color settings
Theme settings
Have a question?
Use color filters
Turn on high contrast
Get help

Windows 10 lets you resize text, independent of display scaling.

THE DOCTOR RESPONDS: Microsoft does seem to like moving settings and changing others altogether. In this case, it may still be possible to achieve what you want without a third-party tool, though. Rather than navigating to "Windows Settings → System → Display," and changing "Scale and layout" from your desired 150 percent recommendation, go to "Settings → Ease of Access → Display," and drag the "Make text bigger" slider until the preview looks how you want.

If that doesn't fix your issue, check out Winaero Tweaker from http://winaero.com. The software exposes a wide range of adjustments for Windows 7, 8, 8.1, and 10. Many of them are accessible through the Registry, but are much easier to manipulate through the utility.

Missing Audio

Dear Doc, I get no audio on my Dell XPS 13 (9343) except for system sounds. I believe the problem is that the Realtek driver does not show up when I navigate to "System → Settings → Sounds." I downloaded a new driver, dated 2015, uninstalled the old one, and re-installed. Device Manager and the Troubleshooter say the hardware is working OK. I'm running Windows 10, version 1809, with all updates. How do I convince the PC to use both drivers?

Separately, I noticed that Microsoft uses eight hexadecimal digits in its error codes. That's over four billion (base 10) error possibilities. With that many choices, why are they so non-specific? An online search for a particular error often yields many results, all of them different. Thank you!

–Pete Reque

THE DOCTOR RESPONDS: You shouldn't have to convince Windows to use multiple audio device drivers unless multiple audio devices are present. According to Dell's specification sheet for the XPS 13 (9343), your system sports a Realtek ALC3263 codec. The Dell support page tells the Doc that the driver file was first released in 2015, but most recently updated in 2018. Grab the newest driver, along with the latest BIOS version. Flash the firmware, completely uninstall your old audio driver, and install the one you downloaded from Dell's site. So long as Device Manager says everything is working properly, it should be possible to open Windows Settings, click the "System" icon, navigate to the "Sound" pane, and select the Realtek Audio output device.

If you still hear nothing, jump into your updated BIOS

↘ submit your questions to: doctor@maximumpc.com

ASRock
X399M Taichi
X399M
Taichi
RYZEN

ASRock's X399M Taichi motherboard is your best bet for a microATX build based on AMD's Ryzen Threadripper CPU.

by pressing F2 at the Dell splash screen. Expand the "POST Behavior" tree and click "Fastboot." Switch to the "Thorough" radio button, click "Apply," then "Exit."

Worst case, there's always the Recovery process ("Windows Settings → Update & Security → Recovery → Reset this PC"). Using the "Keep my files" option, it should be possible to roll back installed apps without losing any of your personal data.

As for Microsoft's error codes, the company's Dev Center has an in-depth guide for creating messages corresponding to helpful solutions. One of its suggestions involves combining text descriptions and codes that make resolutions searchable and specific. This blend of short explanations and hexadecimal is meant to aid in troubleshooting. If you'd like additional help converting a code into something more digestible, open the Windows calculator, switch to Programmer mode, click "Hex," and enter the code's last four characters. Next, press "Dec" to convert the hexadecimal to decimal. Open a command prompt and type "NET HELPMSG" followed by the decimal number. You should get back a more useful explanation of the error.

Building a 4K HTPC

Doc, I was re-reading the September issue about building an HTPC, and it left me wondering about 4K. The article talked about using integrated graphics, making sure the motherboard and CPU had HDCP 2.2 encoder support. However, I plan on building my rig with an add-in graphics card.

To run at 4K, would I still be limited to a motherboard/CPU combo with HDCP 2.2 encoder support if the GPU has it? And would I still need a CPU with integrated graphics? The main reason I ask is that, when I'm running multiple streaming cams, my current system tends to slow down any time the cam count exceeds the core count. Since this would be one of the uses for a new HTPC, I'm looking at a 12 to 16-core Ryzen Threadripper CPU. However, I must have HDCP 2.2 support. So, what components do I need in order to get 4K video support and max out core count?

–Kenneth Marshall

THE DOCTOR RESPONDS: For those who don't know, HDCP, or high-bandwidth digital content protection, is a mechanism that prevents the copying of media as it traverses various connections, including DisplayPort and HDMI. Each piece of your display subsystem must support HDCP to play back content protected by it. And 4K requires HDCP 2.2.

Whether you need to limit yourself to integrated graphics depends on what you're trying to view at 4K. Modern graphics cards from AMD and Nvidia support HDCP 2.2. Moreover, they can stream Ultra HD content from Netflix if you're on Windows 10 with Microsoft's Edge browser, using a compatible 4K display, and paying for a plan that allows Ultra HD playback. The VLC media player (www.videolan.org/vlc/) can take advantage of fixed-function decode hardware in AMD, Intel, and Nvidia graphics engines to accelerate 4K Ultra HD content. Nvidia even collaborated with Open Broadcaster Software to create a GeForce-optimized version of the OBS Studio, which utilizes the company's NVEnc encoder hardware to shoulder some of the workload from your cameras.

So long as you aren't bothered by the larger footprint of add-in graphics cards, there's no reason to avoid a Radeon or GeForce, unless you need Ultra HD Blu-ray support. CyberLink's PowerDVD is the only game in town for that, and it requires Windows 10, a modern Intel CPU on a motherboard with Software Guard Extensions (SGX) support, and on-die graphics with a protected HDCP 2.2 path to your monitor.

Just don't underestimate the challenge of cramming Threadripper and discrete graphics into an HTPC. A 180W (or more) host processor and a fast add-in card generate lots of heat. There's one microATX mobo able to accommodate the pair. Otherwise, you're looking at a full ATX platform in a sizeable enclosure.

My PC Slows Down

I have a desktop PC with a Core i7-7700K, a 280mm all-in-one cooler, an Asus Maximus IX Hero, 32GB of RAM, a GeForce GTX 1070, a 1TB Samsung 960 EVO SSD, a 2TB 850 EVO SSD, a 5TB hard drive, and Windows 10 Pro.

A couple of months ago, I started noticing a problem. After a couple days of uptime, the system started slowing down. I'd click the mouse, two or three seconds would pass, and the action would register. If I reboot, the issue goes away until it starts happening a day or two later.

I checked for viruses, looked at the programs that start with Windows, and monitored what's running when I notice the slowdown via Task Manager. I still can't identify the source. Any help is welcome. **–Dr. John Taylor**

THE DOCTOR RESPONDS: There are many possible causes. Is there anything you remember changing a couple of months ago that might have precipitated this behavior? As you mull over your PC's recent history, the Doc has a few examples of his own slowdowns he'd like to share.

On his home office PC, the Doc must use an old version of a web browser to interface with one client's content management system. This browser is exceptionally "leaky," so to speak. If it's left open for more than a day or two, it consumes gigabytes of system memory, and slows his system to an unresponsive crawl. At work, the Doc's managed service provider has several security utilities installed to protect the IT infrastructure. These have a bad habit of kicking off at the most inopportune times, making it all but impossible to get anything done. One machine in the Doc's lab is subjected to dustier airflow than all the others. If it isn't disassembled and blown out with a compressor on a monthly basis, it randomly slows down and crashes as the cooler fails to keep up with heat, resulting in throttling.

The point is that your culprit could be a legitimate piece of software with a bad bit of code, malware flying under the radar, or even hardware on the fritz. Continue to troubleshoot by curating apps using Windows Settings, monitoring the resource consumption of running processes through Task Manager (sort by Memory, highest to lowest), and checking for updates. The bottleneck could be your storage subsystem, from a full or unhealthy hard drive to an app eating up RAM. A running process might be chewing up processor cycles. Or maybe throttling is slowing down a component that should be running faster.

TITAN RTX

2019 DREAM MACHINE

Return of the king

AT LAST, THE BEAST of bedlam rises again from the mist. Its elegant form glinting in the sunlight, as those charged rays sheen across its metallic surface. Dream Machine 2019 hath cometh, with back-breaking labor, a price list that only the divine could conjure, and a time frame in which to build it that makes memory latencies look lethargic.

Dream Machine is always a labor of love, a challenge undertaken by only the most ardent of PC enthusiasts working for the magazine. Not only does it require an almost barbarous level of organization and charisma to will this thing into existence, but it also stretches those who undertake the mighty burden to the absolute limits of their creative output. As much as you build it, craft it, develop it and hone it, it changes you, it ruins you, it makes you better.

Dream Machine means a lot to us. That name carries weight, and because of that, we refused to craft one of these celestial giants in 2018. Not because we weren't capable, or didn't have the time, but because the environment hadn't changed. The hardware, a piece of the puzzle that's so pivotal to the prominence of this performance king, was lacking. Graphics remained motionless, memory was decaying, solid-state storage was static. The only thing that had changed since 2017 was the number of cores housed within the beating hearts of our machines, and was that enough to justify a Dream Machine? Perhaps, but it would've been a disservice to the legacy of *Maximum PC,* to our readers, and to everyone who has been a part of our community. So, with a heavy heart, we stepped down from the pedestal, and stayed our hand for one more year.

However, that was then; this is now. And with that, welcome to Dream Machine 2019! **–ZAK STOREY**

THE $19,487 MACHINE

IT'S HARD WORK DECIDING what to do with a system like this. Over the years, we've worked our way through giant cases, separate loops, hard tubing, soft tubing, air cooling—you name it, we've done it. This year, though, we decided to try something a little different, something we hadn't attempted in some time: a dual-system rig. That's right, two systems in one case, under one liquid-cooled loop, into which we packed some of the best and brightest hardware we could muster.

1 One of our favorite bends in this build is the D bend connecting the two GPUs together. It took a lot of work and several tries, but in the end we nailed it thanks to a handy cup we had lying about that we could bend around. You've gotta think outside the box sometimes. What's also pretty cool is that it sits on two rotary 90-degree fittings, so you can rotate this entire piece without fear of causing a leak.

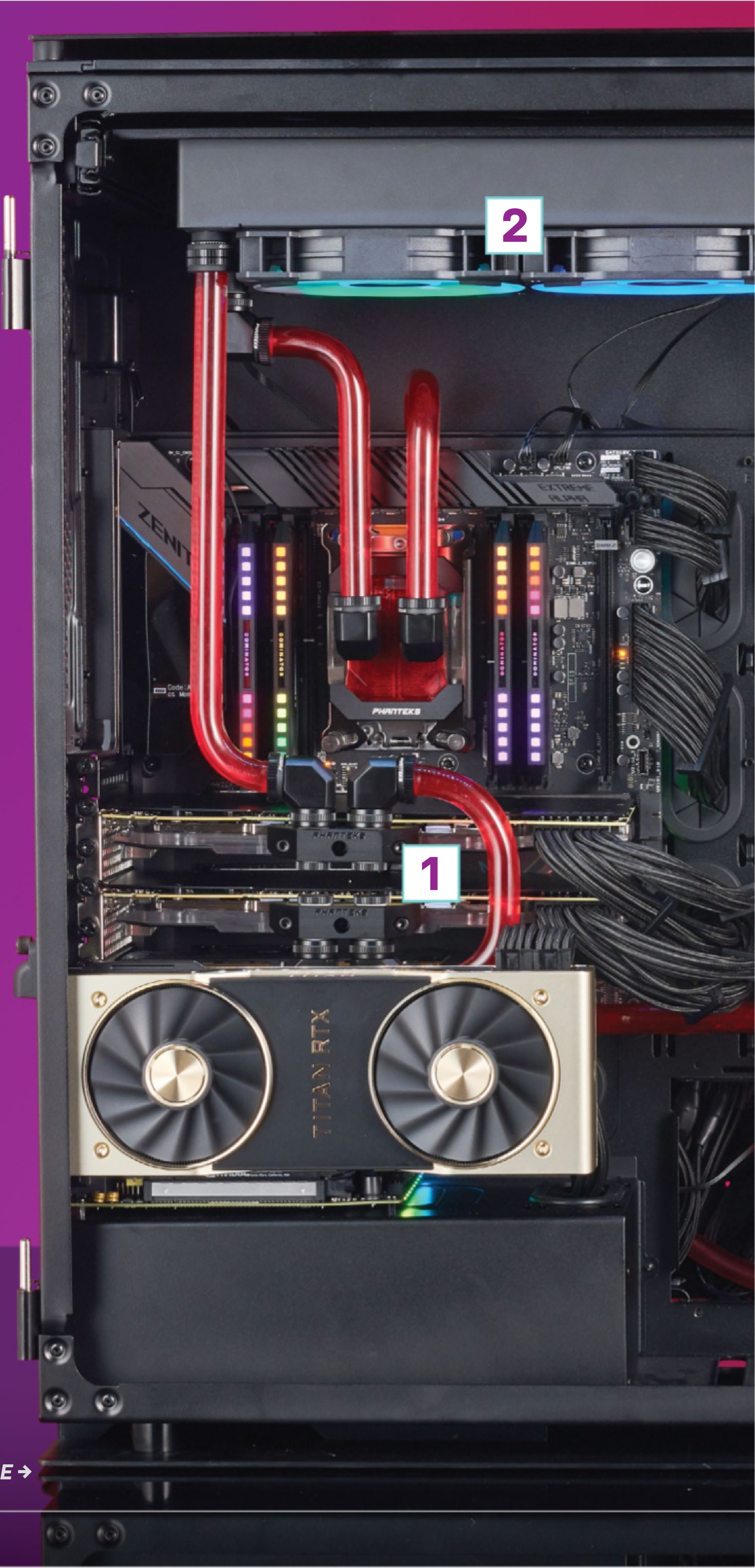
2 We had to mod two parts of this chassis to get it to suit our needs. First, we had to remove the hard drive cage that was riveted in place to allow us to mount the pump/res combo where we wanted. Then we had to move the top radiator bracket half an inch toward the side of the case, so we could line the rad fitting up perfectly with the GPU fitting.

3 Fitting eight fans on a radiator setup like this was challenging, as all eight of them have two cables each. It's no simple task when you have to carefully thread each fan cable up between the middle of the two radiators.

4 We don't say this often enough, but it's so important that you test your hardware before you begin your liquid-cooling journey. Don't be like us and go "Eh, looks all right," then build it all, fill the loop, and realize you've got issues with the parts. By disassembling GPUs and adding waterblocks, you're more than likely to void the warranty.

5 We've added another 24-inch LED light strip up top here—nothing fancy, just pure white, to accent our build. If we're honest, though, this rig would probably have benefitted from a second light strip in the bottom as well, because the case is just so darn big, that you need to flood the thing with as much light as possible.

STEP-BY-STEP GUIDE →



AMD INGREDIENTS

PART		STREET PRICE
CPU	AMD Threadripper 2990WX	$1,730
Mobo	Asus ROG Zenith Extreme Alpha	$650
RAM	64GB (8x 8GB) Corsair Dominator Platinum RGB @ 3,600MT/s	$875
GPU	2x Nvidia GeForce RTX 2080 Ti	$2,342
Storage 1	1.5TB Intel Optane SSD 905P	$2,237
Storage 2	12TB (6x 2TB) PNY CS1311 2.5-inch SSD	$2,700
PSU	1,600W Corsair AX1600i Digital ATX 80 Plus Titanium + cables	$610
OS	Windows 10 Pro	$200
SUBTOTAL		$11,344

INTEL INGREDIENTS

PART		STREET PRICE
CPU	Pre-binned Intel Core i9-9900K @ 5.1GHz	$1,133
Mobo	Asus ROG Strix Z390-I Gaming	$215
RAM	32GB (2x 16GB) Corsair Vengeance RGB Pro @ 3,466MT/s	$360
GPU	Nvidia Titan RTX	$2,500
Storage 1	1TB Samsung 970 Pro M.2 PCIe SSD	$440
PSU	750W Corsair SF750 80 Plus Platinum	$180
OS	Windows 10 Pro	$200
SUBTOTAL		$5,028

SHARED INGREDIENTS

PART		STREET PRICE
Case	Corsair Obsidian Series 1000D Super Tower	$500
Cooling	Phanteks + EKWB Cooling Suite	$2,005
Fans 1	8x Corsair LL120 RGB Dual Loop Fans	$310
Fans 2	3x Corsair LL140 RGB Dual Loop Fans	$300
SUBTOTAL		$3,115

GRAND TOTAL **$19,487**

AMD INGREDIENTS

AMD
RYZEN
THREADRIPPER

PROCESSOR

AMD THREADRIPPER 2990WX

Choosing a primary processor for this year's Dream Machine was tricky. We had two to choose from: Intel's 28-core Xeon W-3175X behemoth or AMD's 32-core Threadripper 2990WX juggernaut.

Dream Machine isn't typically held back by financial considerations, but over the years at *Maximum PC*, we've learned to recognize that price to performance is more important than anything else.

Given that both processors end up very close to one another when overclocked, with each securing wins in a variety of benchmarks in contrast with each other, for the sake of hardware compatibility, power draw, and best bang for buck, we decided to go with AMD's Threadripper 2990WX. This is effectively a workstation build, and combining the 2990WX's enterprise versatility with an unlocked architecture and a ton of grunt performance makes it the king of the processing world right now, at least in this subsector.

MOTHERBOARD

ASUS ROG ZENITH EXTREME ALPHA

When you have a 32-core processor, you need a motherboard capable of handling its power demands. Asus's first-gen Zenith Extreme was a masterpiece of high-end technological wizardry, but it wasn't strong enough to handle the extreme temperatures those VRMs put out when running a 32-core part, so here we have the second generation, the ROG Zenith Extreme Alpha.

With its massive fan-cooled VRM heatsink up top, twin eight-pin EPS powers, eight SATA ports, and phenomenal support for M.2 devices, it truly is the king of X399 motherboards.

MEMORY

64GB *(8x 8GB)* CORSAIR DOMINATOR PLATINUM RGB @ 3,600MT/S

A big system's going to need big memory. In 2017, we splurged on the big capacity stuff, but this time around we're going for something that favors speed over size. Zen cores thrives off high-frequency memory, thanks to the Infinity Fabric's dependency on clock speed, so finding memory that's both high in capacity and frequency lead us to this. There's an unfortunate compromise that has to be made: Most high-end boards don't support 128GB of high-frequency memory, so capacity suffers in favor of speed, but we think it's worth it.

Corsair's Dominator Platinum sticks have long been premium volatile storage darlings, and with the RGB craze running rampant across the rest of Corsair's products, it was only a matter of time before we saw the big D get the RGB treatment. That said, these sure do look the part. Complete with slick black heatsinks, that Dominator Platinum styling, and some intriguing RGB accents, Corsair's pulled it off rather well.

GRAPHICS

(2x) NVIDIA RTX 2080 TI

Choosing which GPUs to use where in our Dream Machine 2019 was hard. Most of our workload tests are oriented around rendering, streaming, and the occasional game. Because of that, and because, aside from memory capacity, the RTX 2080 Ti only trails behind the Titan RTX by roughly 10 percent, we opted to go with Twin Tis complete with waterblocks.

Sourcing two at short notice was tricky, so Case King lent us two European brand cards. These come as standard with a reference PCB, the same one found on the Founders Edition card, so if you're looking to pick up something similar without a European contact, there's a ton of other vendors out there to choose from. We recommend EVGA's Black Edition if you're after a good stock PCB variant card for a waterblock.

PALIT
GEFORCE RTX
PALIT

INTEL INGREDIENTS

TITAN RTX
nVIDIA

GRAPHICS

NVIDIA TITAN RTX

For our second system, and because we're a tad limited when it comes to the number of PCIe slots we have on our tiny ITX board, we've decided to throw caution to the wind, grab our trusty Titan RTX, and throw it in here, too.

Now, aside from its massive complement of 4,608 CUDA cores, 24GB of GDDR6 memory, and 18.6 billion transistors, the one thing the Titan RTX has in abundance is swagger. Yep, we're going to be running our primary system's GPUs under water and overclocked, but our Titan RTX will be acting as the showpiece for our build. There's nothing we love more than to see fans spinning around, and a vertical PCIe bracket allows us to do exactly that. Together with the RTX Titan's extensive gold dual-fan cooler design, we're more than happy to run it in our ITX build.

CORSAIR
VENGEANCE RGB PRO

MEMORY

32GB *(2x 16GB)* CORSAIR VENGEANCE RGB PRO @ 3,466MT/S

For our second gaming rig, if you can call it that, we've leaned on Corsair again to provide us with the necessary memory modules. We knew from the outset that these sticks were going to be hidden away, so it was less about appearance (and, let's face it, they're not the prettiest sticks in the shed), and more about pure grunt and size. Again, we've gone for as much as we can get on the platform, and that means 32GB of prime grade A memory estate, running at 3,466MT/s.

Intel won't gain as much here from that high frequency, but combined with the Titan RTX and video rendering, it'll provide some benefit across the board.

PROCESSOR

PRE-BINNED INTEL CORE I9-9900K @ 5.1GHZ

All work and no play.... What would a good Dream Machine be without the capacity to game well? That's our logic anyway, and having two systems in this rig means exactly that—we need one to switch to when we want to hit those frame rates hard.

Intel's Core i9-9900K is the absolute king of gaming right now. With ridiculously high single-core IPC performance, impressive cooling, plus a thwopping eight cores, and 16 threads at its disposal, this monster should be more than a little handy in the gaming stakes. We've picked up a pre-binned chip from Case King Europe for this build, and boy does that come with a price jump. However, a guaranteed 5.1GHz is just too tasty to say no to.

Why not game on the 2990WX? Well, you can, but it's predominantly a workstation part—keeping all 32 cores enabled on a chip like this isn't going to help you out much in the world of frame rates. There's a lot of magic happening behind the scenes with those memory channels and core complexes, and there are potential frame dips to be had if you don't enable game mode in Ryzen's Master Utility.

MOTHERBOARD

ASUS ROG STRIX Z390-I GAMING

We know what you're thinking—that we asked Asus for the Alpha, and it said "Yeah, but can you use the Z390-I for the ITX system as well?" Well, you'd be right. It did. But this is one of the best-looking ITX boards out there, second only to EVGA's Z170 Stinger from way back when (someone needs to remind Zak 2015 isn't "way back when").

On top of that, it's also got a pretty snazzy rear I/O cover, integrated I/O shield, and built-in M.2 heatsink, and it supports 32GB of standard DDR4 (or 64GB of double capacity) up to 4,600MT/s speeds. Yeah, some of the front I/O headers are a bit out of the way, but otherwise it's a tidy little number, and should be more than capable of pushing our pre-binned chip's 5.1GHz overclock with ease.

STRIX
REPUBLIC OF GAMERS
EDGE
VELOCIDAD

AMD INGREDIENTS

intel
Intel® Optane™ SSD 905P

PNY
SOLID STATE DRIVE

STORAGE

1.5TB INTEL 905P PCIE SSD & 12TB *(6x 2TB)* PNY CS1311 2.5-INCH SSDS

Storage has always been something of an Achilles heel for Dream Machine. No matter what we do, no one is happy. If we use mass-capacity spinning hard drives on site, the backup squad come complaining; if we ditch that entirely, just run PCIe SSDs, and talk about a NAS solution instead, we get complaints that it costs too much.

It's a tricky act to balance, that's for sure. However, for our primary system, there really was only one SSD we were going to use, and that's Intel's 905P 1.5TB drive—this thing is a monster. Although not as impressive with its sequentials as some of Samsung's 970 Pro drives, what Optane lacks in those default advertising materials it more than makes up for in low latency and high random 4K performance.

We're coupling the 905P with 12TB of SSDs from PNY to act as our onsite backup. We'll be running these in RAID 10, to give us a combination of ridiculous sequential speed and redundancy, because we can.

CORSAIR
AX1600i

PSU

1,600W CORSAIR AX1600I DIGITAL PSU 80 PLUS TITANIUM

This is total overkill for what we're doing with this system. At most, we expect 900–1,000W from the wall under load with overclocks. That said, there's significant headroom if we decide to go with even more GPUs further down the line.

You get the usual collection of 0dB fan tech, modular cable setup, magnetic color-coordinated name plaques, and more. We've also forked out for the Pro cable kit, featuring cable combs and a nicer braided finish across all the cables, rather than just the main ones.

SHARED INGREDIENTS

CASE

CORSAIR OBSIDIAN 1000D

Corsair has a pedigree when it comes to high-end chassis, and we knew from the get-go that we absolutely wanted to take up the opportunity to work inside its new flagship box, the Obsidian 1000D.

This thing is phenomenal in size, capable of housing up to eight 120mm fans in the front alone, 16 if you're using twin 480mm radiators, as we are, and a further three 140mm ones in the roof. It's monstrous. And heavy. Fun fact: For every shot we take for the step-by-step guide, we actually build it off-set, then lift it on to the set for the shot, to protect what we're shooting on. And it is killer.

We've also got massive liquid-cooling support, a plethora of tempered glass, a huge fan and RGB LED controller in the back, some fairly intriguing cable management options, and an awesome amount of space in it for tubing runs.

CoolStream CE

LIQUID-COOLING

EKWB, PHANTEKS, ALPHACOOL, & MAYHEM

There's a whole armada of parts here, from multiple manufacturers. Alphacool is providing the tubing, EKWB the reservoir and radiators, and Phanteks all the blocks and fittings.

We were a little reluctant at first to go with Phanteks blocks, given how new they are to the industry; however, after working with them, it's all been rather painless, and they've got some neat,

PSU

750W CORSAIR SF750 PSU 80 PLUS PLATINUM

INTEL INGREDIENTS

Another Corsair power supply, but this one's a bit more special. For our choice of case, we knew we were going to need a second, super-small form factor power supply for a secondary system, and this one absolutely fits the bill. It's around two-thirds the size of a small bottle of Coca-Cola, and that size coupled with the fact that it has a modular design, comes with braided cables, and has 0dB fan tech again is just nuts.

We're not too sure how quiet that fan's going to be in reality just yet, but it's an impressive spec sheet for a PSU, that's for sure. Again, we're hitting that 50 percent sweet spot under load with this second system, and we're expecting a power draw of about 370W without overclock.

STORAGE

1TB SAMSUNG 970 PRO PCIE SSD

For our "gaming" ITX system, we're using a single 1TB Samsung 970 Pro PCIe SSD, partitioned up with 333GB dedicated to the OS, and the rest to the games we'll be running or streaming.

The 970 Pro truly is the king of 3D NAND, and although it lacks the 4K firepower of Intel's 905P, it's perfect for quick sequential throughput, such as rendering, streaming, and media creation. Impressively, it's also rather affordable for a 1TB drive, and comes with a good warranty as well. We'll also be tapping into our 12TB of RAIDed drives via networking for backups and anything else we might need to store there.

space-saving tricks up their sleeves when it comes to the angled fittings that we adore. More on that later.

For this Dream Machine, we'll be trying something a bit different. We usually run two loops across one rig, but this time we'll be running one loop across two separate systems. It's part of the reason why we're taking advantage of three massive radiators, and an incredible 1,380mm of total fan and radiator coverage.

For coolant, we're of course going with Mayhem's Aurora X1 again. It just looks good—real good—and we're a real fan of flashy with these builds.

FANS

(11x) CORSAIR LL120/LL140MM DUAL RING FANS

What better way to finish all that off than with a ton of fans? These LL ring fans from Corsair have to be some of the best-looking fans we've seen, and although they're not a perfect fit for your standard AIO radiator, for our aftermarket liquid-cooled rads, they're more than capable.

That's in part down to the fin density of the radiators we using here—due to the thinner radiator size, all-in-ones typically feature denser radiator fins, as opposed to bigger radiators, which are more dispersed, thus requiring less static pressure, and more pure airflow to effectively dissipate heat.

We're also going to be running a positive setup on this build, for no other reason than it looks good.

2019 DREAM MACHINE

STEP-BY-STEP BUILD IT GUIDE: DIVING INTO THE COMPLEXITIES OF THIS TITANIC BEAST

LENGTH OF TIME: **20–30 HOURS**

LEVEL OF DIFFICULTY: **EXTREME**

1 TWIN SYSTEM PREP

THIS TIME AROUND, our Dream Machine is extra special, because we're fitting two full systems in one super-tower chassis, under one cooling loop. It's a complex affair, but the first thing we knew we needed to do was prep both the motherboards. That meant seating the CPUs into their respective LGA sockets, installing the memory, and more importantly, installing the CPU blocks ahead of time.

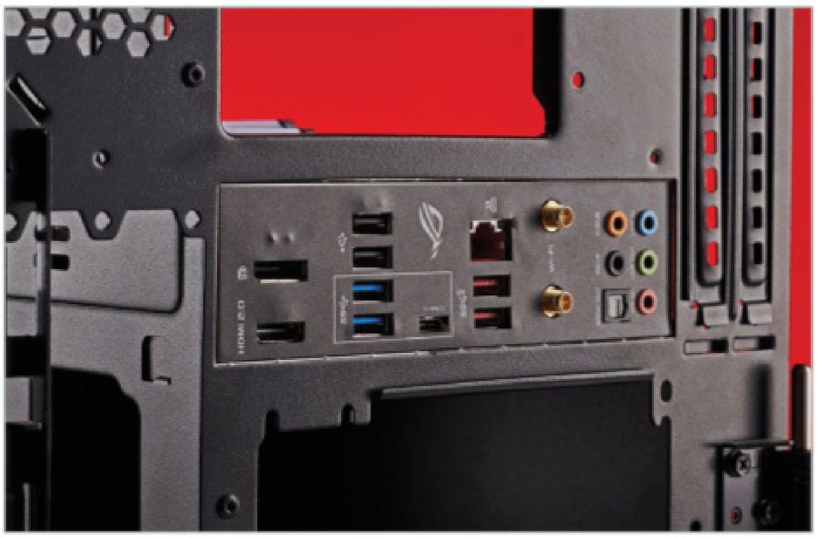
The Phanteks blocks are actually fairly simple to fit, with the only noticeable challenge being the backplate on the ITX build requiring us to position the stand-offs correctly. Other than that, they also come with RGB cables. Those are a little funky to set up, and if we're honest, we're not convinced they add much, so we haven't installed them (there will be enough lighting shenanigans later on anyway).

2 THE FIRST CHALLENGE

ONE OF THE BIGGEST ISSUES we had with this case stemmed from how the ITX motherboard fitted in it. Or, we should probably say, didn't fit—there was clearly a conflict somewhere stopping the board's integrated I/O shield fitting in place, and allowing us to line the mobo up with the stand-offs.

In the end, we had to entirely dismantle the backplate (no easy task, as it requires you to unscrew the rear I/O heatsink from the bottom, the sides, and the top, then yank the I/O plate out), break a few clips, remove one part of the heatsink, then reinstall the lot back into the system, with the PCIe bracket for the main system above removed. Yeah, it was a nightmare, and one of the first pitfalls of the 1000D.

It's particularly frustrating given that this is a $500 chassis and the most premium ITX Z390 motherboard you can buy.



3 TEST FITTING GPUS

ONCE THOSE ITX STRUGGLES were out of the way, it was time for us to do some test fitting with the GPUs we'd blocked up earlier. Running them in this three-slot fashion was our original plan—however, as the clearance between the bottom-most card and the CPU block in the ITX system narrowed, and we knew we had to run piping down there as well, it seemed less and less feasible.

We tried multiple combinations—installing the PCIe SSD in the middle, swapping everything around, removing the SSD. In the end, we settled for the configuration we have at the very end of the build, populating both the first and second PCIe slots. Although that would lead to its own issues later on....

4 RADIATOR FITTING

BOY, THIS CASE IS BIG, and the more hardware you add, the heavier it becomes. It's certainly not easy to it lug around, and installing twin 480mm radiators in the front, along with a 420mm in the roof, doesn't help matters either.

The real issue here, however, was the fans, thanks to the ridiculous number of cables required to power and control the LED ring fans (two per fan). The fact we had eight of them in the front alone meant we had to do some wizardry when it came to getting all four of the fans closest to the side panel cabled up. In short, we wired them up between the two rads, and rested them on top, but installing them, even with the pull-out radiator trays, was no easy task.

5 TITAN FOR DAYS

NOTHING SAYS PREMIUM like a Titan RTX beating away at the heart of your system. And in our case, this was the first time we'd started to see the whole thing come to life. Fitting the Titan here is a bit of a controversial decision—it's a developer card, so if anything, it should be in the primary rig up top.

That said, it's flashy, and we're keeping the cooler on this one, so we'll be using those gold accents to really make the rig pop. There's not a whole lot to report here; this is one of the few things that actually went in fairly easily, although we did have to remove it over and over again to do any sort of work anywhere else.

6 ANNOYING POWER SUPPLIES

ANOTHER FRUSTRATION of the 1000D reveals itself when you go to install the PSUs. In short, if you are thinking of investing in this chassis, always, always, always install your power supplies first. There's absolutely no way of installing the ATX PSU without removing the PSU cover, including whatever's installed above it.

Nope, you can't install it from the side, from the back, from anywhere. It's just, well, not good, that's for sure. And, yep, in our case, we had to remove the Titan, take out the GPUs, then dismantle the rear PCIe bracket, and remove the ITX system to take out the PSU cover, and finally install the PSU. Fun and games—there were lots of profanities muttered in the photo studio when we realized what hoops we had to jump through.

7 FITTING RUNS & RESERVOIR FUN

ONE THING IN THE 1000D'S FAVOR is that it's fairly easy to mount an EK reservoir on this backplate; there are plenty of holes to mount that pump/res combo. This is also where we worked on our first fitting placements.

It's at this point that we were thinking about effective tubing runs, the big one being the run between the two GPUs on the right. We had two options here. We knew we were going to run it in a curve, but we could either keep it short between the two cards, before the cables, or make it reach out further, then have the cables actually inside the circular tubing run.

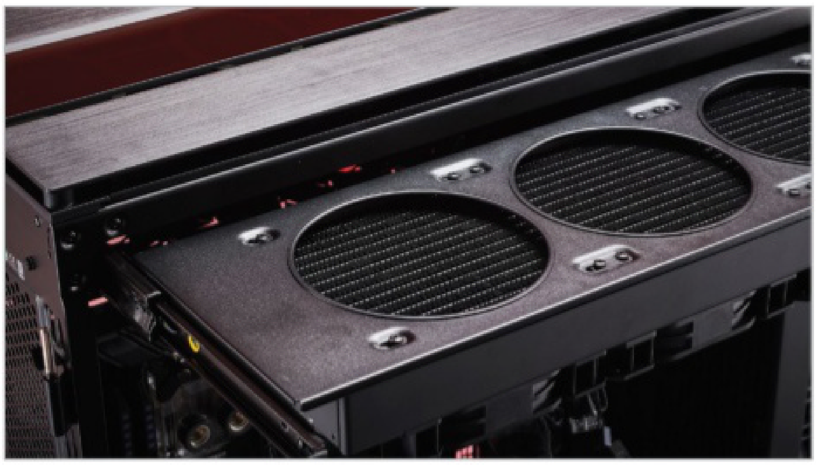
You'll also notice that we've removed the hard drive caddy below the reservoir. It's pop-riveted in place (why? It's a $500 chassis!), so you can't remove it without drilling it out—if that sounds annoying, it's because it is.

8 RADIATOR MODDING

MORE DRILLING—this time to move the top radiator into a the position we wanted. Annoyingly, you can only fit a 140mm diagonal size radiator up top, and only in one position. The radiator bracket itself doesn't fit any other mounting locations or points at all for a 480mm radiator.

Now, that would be fine, but one of our tubing runs (the one running from the upper-most GPU to the radiator) would be at a diagonal slant if we did that, so we cracked out the drill, widened two existing tertiary holes, and freshly drilled two others so we could slide the top bracket along a bit, and bring it into alignment.

As you can see from the shot below, even with our modification on that sliding rail, the bracket itself is still a good inch away from the edge, so why did Corsair design it this way? We don't know—it's another annoyance on the long list of annoyances we have when it comes to this chassis.

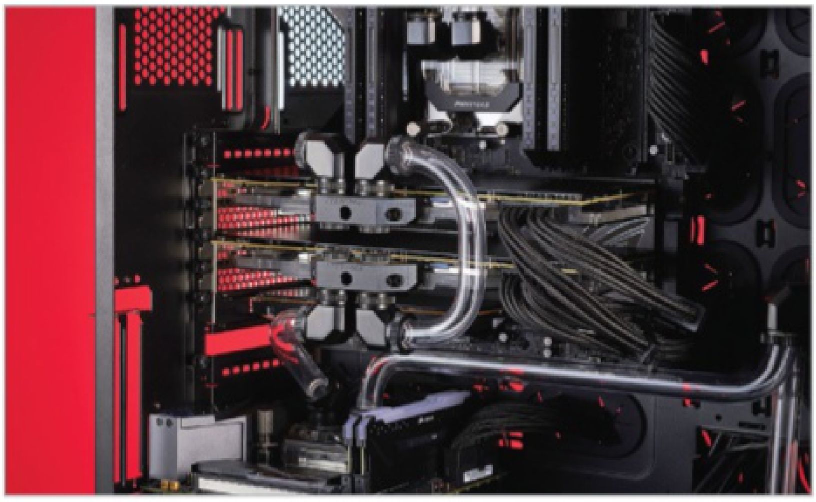


9 WORKING THAT TUBING

AND HERE WE HAVE THE MAJORITY of the tubing runs in place. Or at least, the three difficult ones. Good liquid cooling is actually fairly simple to pull off; the majority of the time, to make a clean-looking build, all you need to be able to do is a 90-degree bend. Once you've got that mastered, you can use fittings to make up the rest.

Take the run from the ITX CPU to the bottom-most GPU: It comes out of the CPU at a 45-degree angle, then straight into the 90-degree fitting on the GPU. It's just a single straight piece with a 90-degree bend.

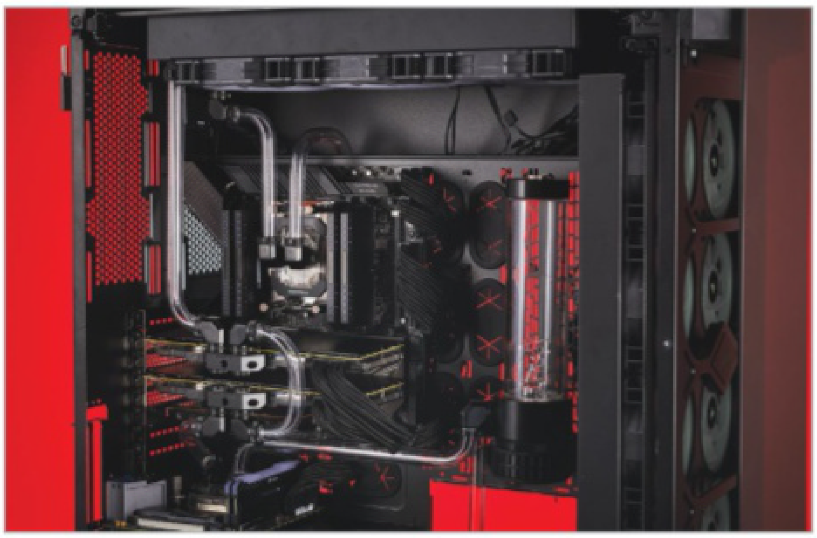
The tubing run from that same CPU to the reservoir? One 90-degree at one end, another 90-degree at the other end. Simple. You'll find a lot of the pros simply stick to single 90-degree bends—it makes a build look infinitely cleaner, and it's also a hell of a lot easier to do.



10 CPU RUNS

THE FINAL COMPLETED LOOP in all its glory. The CPU loop going into the back of the chassis is effectively two 90-degree bends going through a cable grommet. On the other side, a standard G1/4 fitting connects to an Alphacool bulkhead fitting, then to a soft tubing fitting. Then we've run soft tubing all the way down through the back of the chassis and into one of the front radiators. This saves time, and because it's out of the way, it shouldn't be seen too often either.

If we were to update this in the future, we could add a 90-degree fitting on that radiator, pointing up, run a length of tubing up to another 90-degree fitting, attached to a bulkhead pass-through at the top of the case, then run a length of hard tubing through the back of the chassis, and into the CPU that way. It would add another element and look mighty fine, too.

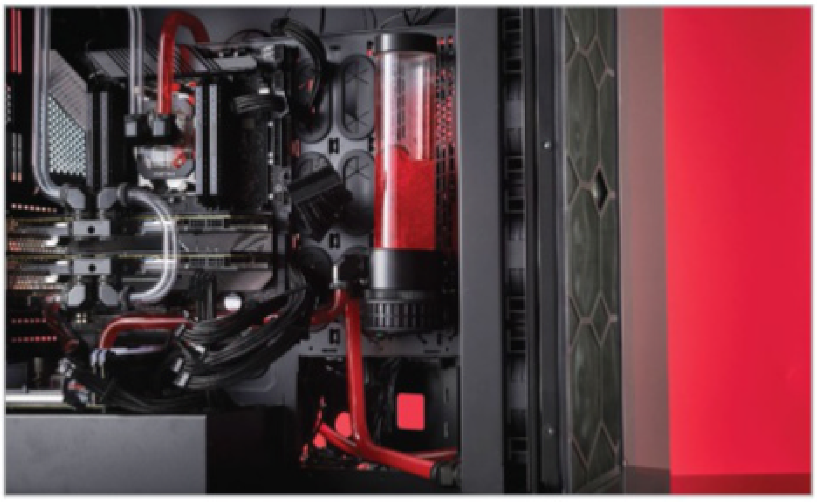


11 LOOP FILLING

WE TURNED TO Mayhem's Aurora coolant once more for this build, using that glorious red fluid to really bring out the look of this system. It took a little over half a gallon to fill this build, adding even more weight to it. And it wasn't without problems.

It mostly came down to the power supply being too beastly for our wall sockets. The 1,600W PSU in our system blew up extension leads, wall plugs, all sorts. At first, we had no idea what was going on. Did we have a dead pump? Was there a short in the PSU? Was the cable plugged in properly? Did the pump's fan header have to be plugged in?

We actually used one of our personal rigs to "jump start" the pump. We knew that machine worked, so we hid it in the back (for photography's sake), then used it to cycle the pump. It was a quick and simple way to diagnose the problem, and after that we managed to get the system running of its own volition.

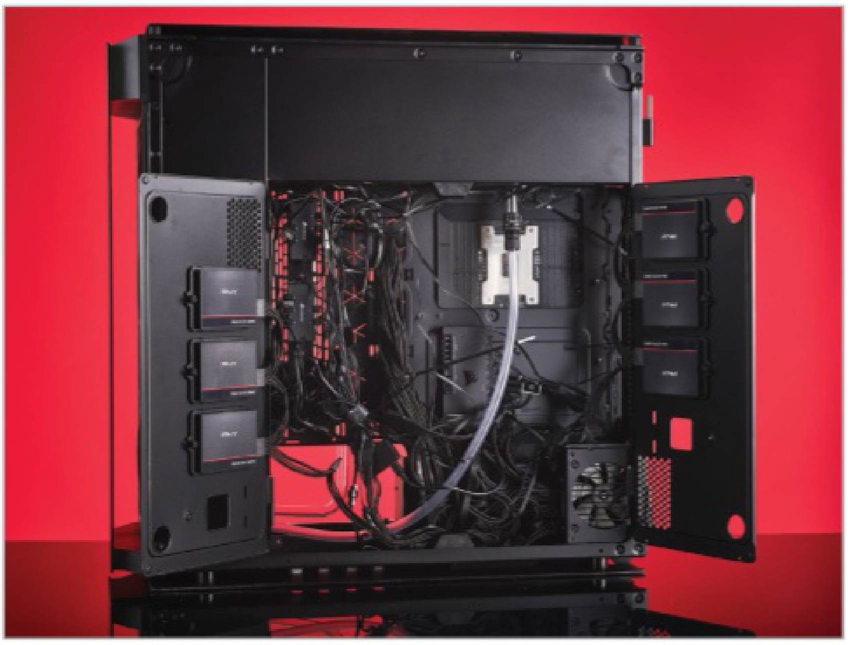


12 CABLE GUISE

ONE FINAL SHOT of the rear of this monstrosity. Usually, we don't spend a whole lot of time on cable management—around 20–30 minutes or so. But with Dream Machine 2019, it took us two whole hours to get all the cabling sorted. All 11 fans needed to be plugged in to a fan controller, a header, and a lighting hub of some description, then daisy-chained together.

Corsair was kind enough to include six PWM fan extension cables with the 1000D, along with a fan controller capable of supporting six fans. No splitters, or anything like that. You know, in a case that can support upward of 24 fans.

We had to reach into the store cupboards and grab as many Noctua fan splitters as we could find, before trying to sort out this tangled mess and get it somewhere resembling tidy. On top of that, once the SSDs were plugged in, it became impossible to open the left door here, because the SATA cables simply aren't long enough. A rough day, that's for sure. You can also spot that final tubing run in this shot, running from the Threadripper 2990WX to the front radiator.



A BATTLE OF WILLS

IT'S HARD NOT TO mention the flaws with this case. There's a lot of problems with it, ones we're surprised Corsair let through the net on such a flagship product. Yet, when all's said and done, on the whole this thing looks baller. The front glass panels, the tubing runs, and the overall quality of the exterior panels are impeccable. The interior could do with some work, but all in all, it looks pretty darn cool.

Using Phanteks for our liquid-cooling gear was also an interesting step away from what we're used to. We love the company's cases, but cooling with it was a first. There's a lot to love and a lot to query. Take the GPU backplates, for instance—they come with 1.5mm Allen screws, yet no Allen wrench. On top of that, unlike most competitors, they're purely for show; there are no thermal pads or contact made with the back of the card outside of screw holes.

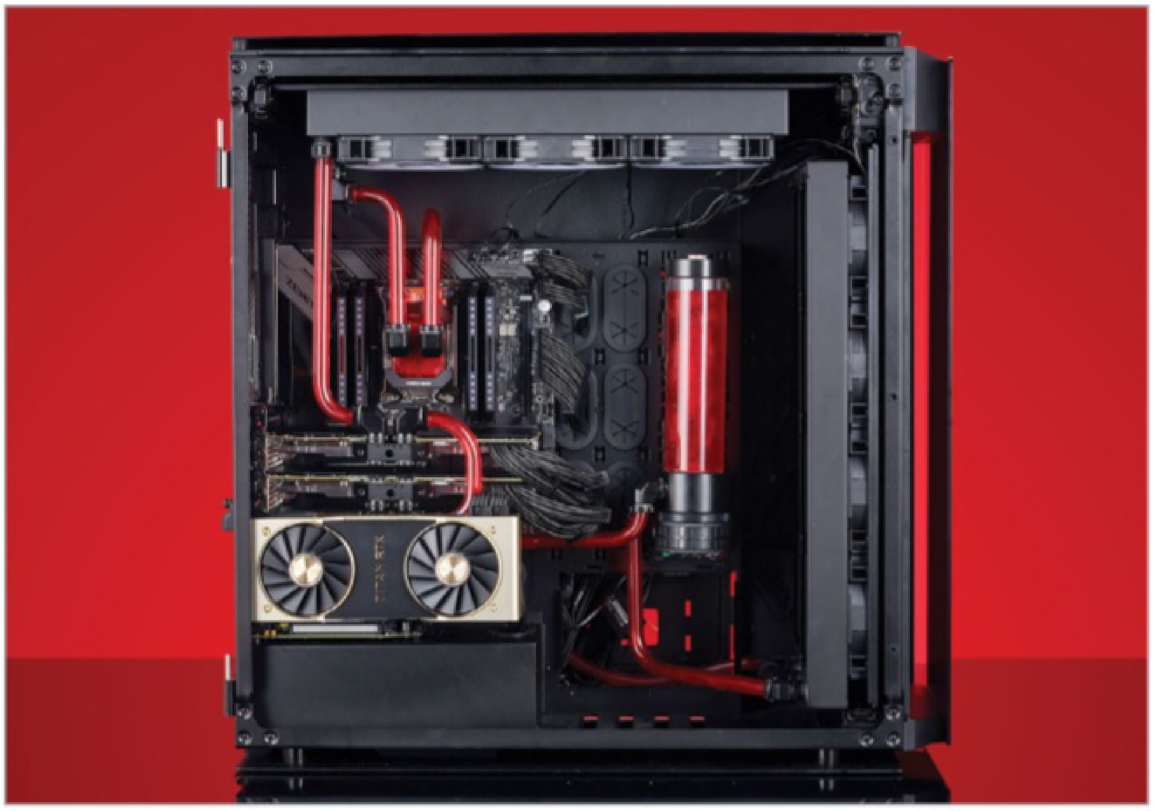
One thing we did love was the fittings, particularly the angled ones. By design, these come with a compression fitting pre-attached. Typically, with EK or Alphacool, you use a rotary angled fitting, then attach a bulky compression fitting of some description to that. With Phanteks, there's no need to add that fitting. It comes with a slim securing fitting on top, an o-ring, and that's it, reducing the overall size, and making it look far cleaner. They're a bit bulky, and they are very angular, but on the whole, they're a pleasure to work with. The downside is that you can't connect multiple angled fittings together, and use two 90s in conjunction, say, or two 45s to make an extended 90.

That aside, there wasn't a whole lot of issues here. You might have noticed we only managed to get four sticks of memory into the Zenith Extreme Alpha. This was a delay on Corsair's part, as it had forgotten to ship the second kit to us until we queried it two days before delivery. Rest assured, however, the second kit did arrive, but the day after the photo shoot, annoyingly.

So, now we've got the building elements out of the way, what would we do differently? Well, outside of replacing that soft tubing with hard tubing and a bulkhead pass-through at the top of the chassis, not a whole lot. Perhaps we'd go for some better cables, and a smaller PSU for the main system; 1,600W is a bit overkill, and doesn't seem to be doing anything other than causing us problems. On top of that, this case is screaming out for custom panels. That bottom PSU cover is just, well, a bit tacky, if we're honest. If we could replace it with a full-length panel, and do something about that rear motherboard tray, this thing would be in a much better place. Perhaps it's time we delved into the world of CAD/CAM, and got some custom milled pieces into the mix. Who knows?

Hardware-wise, we would love to rotate things around a bit, too. Throwing two blocked-up RTX Titans in the top machine, then a single RTX 2080 Ti in the Core i9-9900K would be far superior, perhaps replacing the RTX Titan with an Asus ROG Poseidon.

All issues that will have to be addressed in 2020's Dream Machine….



CONCLUSION
LITTLE DREAM & BIG DREAM

WHAT A ROUGH OLD FIGHT it's been to get this thing up and running. Oh boy, when it came to testing this behemoth, it didn't exactly play ball. The main system's motherboard decided to have a dead memory slot on arrival, along with a couple of bent pins in the socket, requiring a complete mobo swap out, and the ITX rig wouldn't put out any display signal at first. What does that mean in practical terms? Well, it resulted in us having to awkwardly drain the entire loop (not exactly easy with a chassis that weighs 65lb on its own, never mind all the hardware installed inside), then disassemble the system, replace the faulty hardware, and get to work, adding another two days to our overall build time. In the print industry, with fixed deadlines, we can tell you now that ain't exactly a fun proposition.

Anyhoo, we managed to get all that fuss and bother out the way, and here we are now, ready to divulge those glorious benchmark figures. To give a good comparison against an equally ridiculous high-end system, we're running this build up against 2017's Dream Machine. That might sound a little facetious (especially given the fact we're running two systems in this rig versus 2017's single system), but let's face it, both machines are roughly $15K in price, and we don't actually have a comparable zero-point at that price point.

So, on to the results—how did it do? Well, our main system's an interesting one to compare. The AMD Threadripper 2990WX comes packing a total of 32 cores and 64 threads. That's a lot, and unsurprisingly, there are very few programs that really take advantage of that number of cores on the desktop platform. In fact, outside of Cinebench R15, neither of our two remaining rendering benchmarks showed any significant performance improvements over 2017's Intel Core i9-7900X. Interesting, huh? Amazingly, when both rigs are overclocked, the 2990WX actually beats the Intel Core i9, but apart from that, it's really difficult to compare the two effectively.

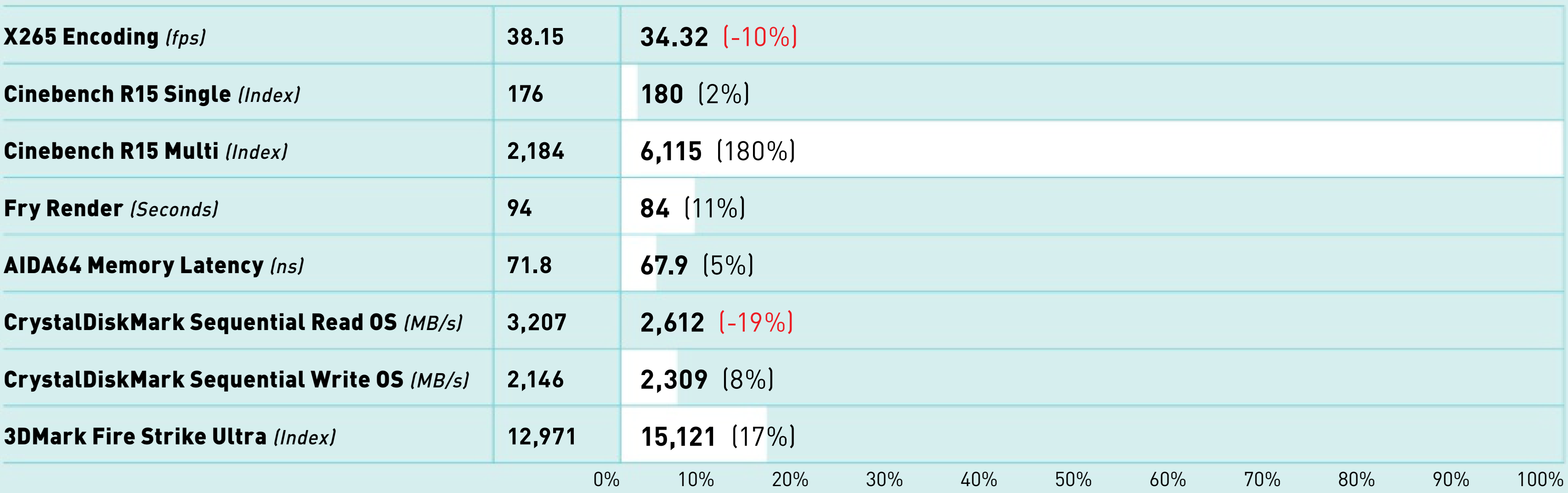
Even more interesting is how far our little Intel build has come. That Core i9-9900K absolutely dominated the i9-7900X, achieving higher single-core, multicore, and x265 encoding scores. That's seriously impressive given the fact that a standard (not pre-binned like ours) Intel Core i9-9900K comes in at near enough $500 less than the 10-core giant, even today.

When it came to gaming, the two systems performed very differently from each other. Impressively, the Pascal Titan XP SLI setup we had from 2017 still punches well above its weight in the 4K department. That said, although it beat the single RTX Titan by a considerable margin, it couldn't hold a candle to the twin RTX 2080 Ti setup we had housed in our main AMD rig. It's worth noting that for our AMD gaming tests, we had the Threadripper 2990WX set to game mode in the Ryzen Master software, disabling 16 of its cores in favor of more streamlined memory performance.

As both our SSD setups are known entities, there's not a lot to report on, other than they work well, and our RAID 10 six-2TB SSD backup array should keep this build ticking along for a while.

So, are we happy? Yes and no. As always with PC building, there are things we would tweak, the big one being the chassis. If we'd found something capable of housing two full-sized ATX rigs, that might have been a far more superior build. Punching the Titan (plus perhaps another one) into the Threadripper build, then the two Tis into a full-sized Intel build for our gaming enthusiasts would have been a far stronger solution, but far more costly, too. Perhaps a desk build is in order for next year?

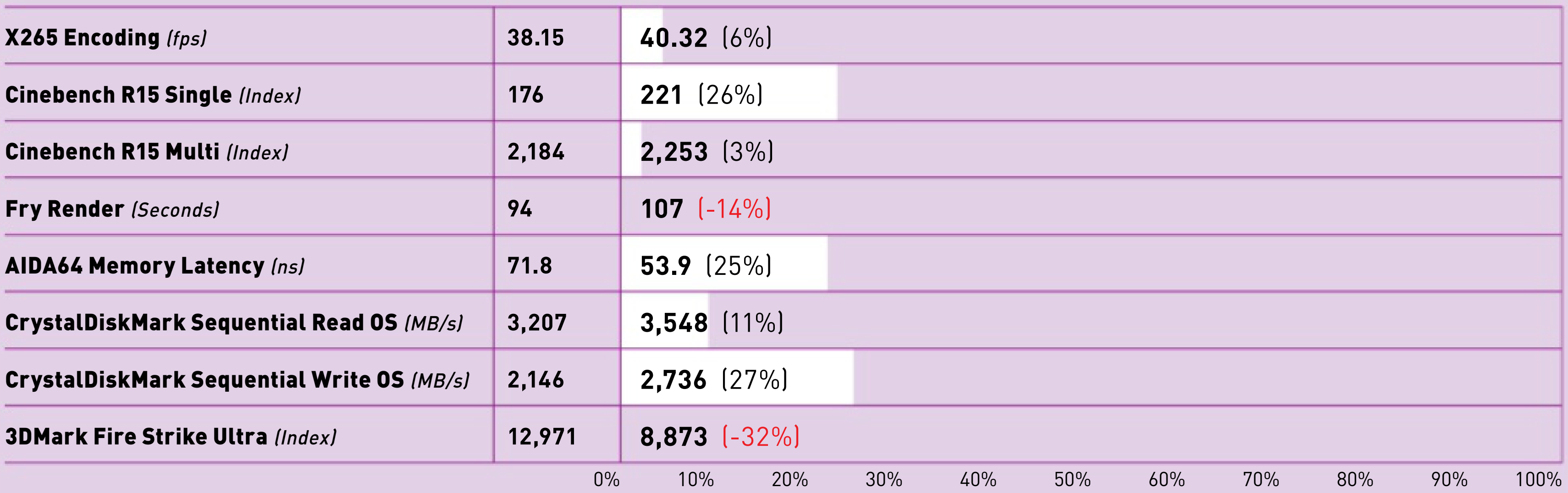
AMD BUILD BENCHMARKS



	ZERO-POINT	DREAM MACHINE 2019
X265 Encoding *(fps)*	38.15	**34.32** (-10%)
Cinebench R15 Single *(Index)*	176	**180** (2%)
Cinebench R15 Multi *(Index)*	2,184	**6,115** (180%)
Fry Render *(Seconds)*	94	**84** (11%)
AIDA64 Memory Latency *(ns)*	71.8	**67.9** (5%)
CrystalDiskMark Sequential Read OS *(MB/s)*	3,207	**2,612** (-19%)
CrystalDiskMark Sequential Write OS *(MB/s)*	2,146	**2,309** (8%)
3DMark Fire Strike Ultra *(Index)*	12,971	**15,121** (17%)

Our zero-point consists of an Intel Core i9-7900X @ 4.6GHz, 128GB of Crucial Ballistix Elite DDR4, 2x Nvidia Titan Xps, and 2x Samsung 960 Pro 512GB running in RAID 0.

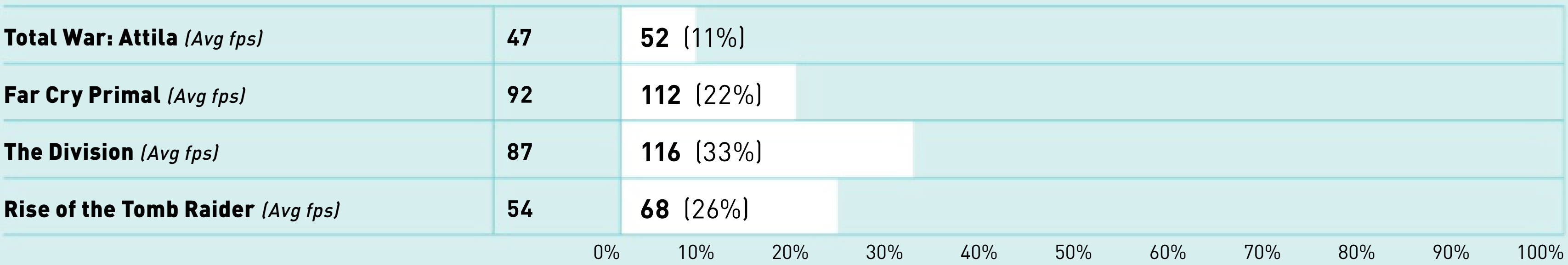
INTEL BUILD BENCHMARKS



	ZERO-POINT	DREAM MACHINE 2019
X265 Encoding *(fps)*	38.15	**40.32** (6%)
Cinebench R15 Single *(Index)*	176	**221** (26%)
Cinebench R15 Multi *(Index)*	2,184	**2,253** (3%)
Fry Render *(Seconds)*	94	**107** (-14%)
AIDA64 Memory Latency *(ns)*	71.8	**53.9** (25%)
CrystalDiskMark Sequential Read OS *(MB/s)*	3,207	**3,548** (11%)
CrystalDiskMark Sequential Write OS *(MB/s)*	2,146	**2,736** (27%)
3DMark Fire Strike Ultra *(Index)*	12,971	**8,873** (-32%)

Our zero-point consists of an Intel Core i9-7900X @ 4.6GHz, 128GB of Crucial Ballistix Elite DDR4, 2x Nvidia Titan Xps, and 2x Samsung 960 Pro 512GB running in RAID 0.

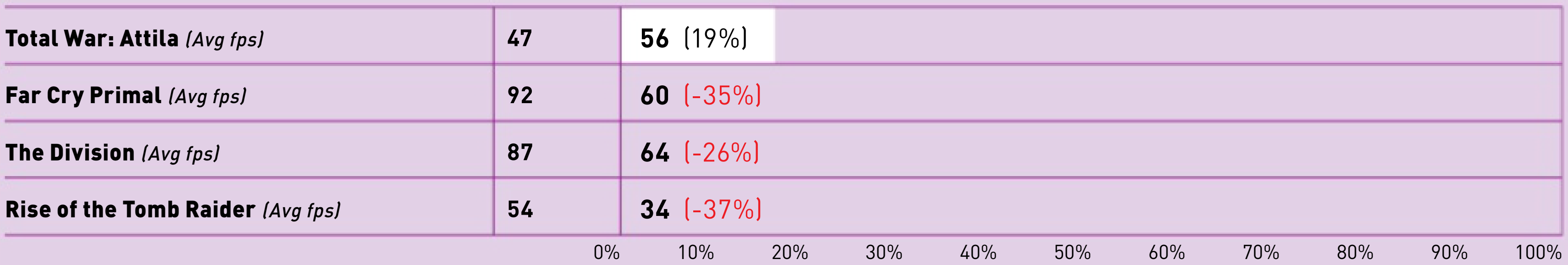
AMD BUILD 4K GAMING BENCHMARKS



	ZERO-POINT	DREAM MACHINE 2019
Total War: Attila *(Avg fps)*	47	**52** (11%)
Far Cry Primal *(Avg fps)*	92	**112** (22%)
The Division *(Avg fps)*	87	**116** (33%)
Rise of the Tomb Raider *(Avg fps)*	54	**68** (26%)

Our zero-point consists of an Intel Core i9-7900X @ 4.6GHz, 128GB of Crucial Ballistix Elite DDR4, 2x Nvidia Titan Xps, and 2x Samsung 960 Pro 512GB running in RAID 0.

INTEL BUILD 4K GAMING BENCHMARKS



	ZERO-POINT	DREAM MACHINE 2019
Total War: Attila *(Avg fps)*	47	**56** (19%)
Far Cry Primal *(Avg fps)*	92	**60** (-35%)
The Division *(Avg fps)*	87	**64** (-26%)
Rise of the Tomb Raider *(Avg fps)*	54	**34** (-37%)

Our zero-point consists of an Intel Core i9-7900X @ 4.6GHz, 128GB of Crucial Ballistix Elite DDR4, 2x Nvidia Titan Xps, and 2x Samsung 960 Pro 512GB running in RAID 0.

CREATIVE
Sound BLASTER X7
SBX

THE SOUND OF SILENCE

Do you need a soundcard in 2019? Phil Iwaniuk **explores the options**

WHEN WE'RE ROLLING off our system specs in forum signatures, water cooler conversations, wedding speeches, and the like, we generally don't tend to go into much detail about the audio componentry. After all, how many of us actually know the capabilities of our onboard sound chips? And who can tell the difference between 16-bit and 32-bit audio anyway? "Enough mini-jacks to connect a 5.1 speaker system" just doesn't roll off the tongue as readily as "four RTX Titans," and while we're able to measure the difference between video components almost too easily—hands up who plays every game with an FPS counter in the top corner—the same simply isn't true when it comes to sound.

That makes it tricky when we ask: Should we get a soundcard? We can't quantify the question with a numerical performance increase, like the extra 12fps that a new CPU will buy you. Yes, bitrate matters, and we've all learned through decades of downloading totally legitimate MP3s that higher is better. But would you notice those ethereal higher soundcard specs in a game, or watching a movie on your PC?

The question's muddied even further by the advent of external DACs, or digital-to-analog converters. These perform a very similar job to the traditional soundcard, but they live outside the machine, and usually feature simpler inputs and outputs. So, even once you've established that upgrading beyond your mobo's onboard sound is a good idea, there's a fork in the road straight away.

So, here we are in 2019, decades after soundcards entered the enthusiast space as desirable pieces of gear, still unsure of their merits and functions. It's time to shine a light on PC audio, and establish which hardware solution is best for you. We'll cover the most likely scenarios: gaming, multimedia, and music production. It's time to answer the question that's been bugging you for years: Do you need a soundcard?

THERE'S A FUNDAMENTAL difference between motherboard sound, discrete soundcards, and DACs, and it all pertains to signal-to-noise ratio. You see, the inside of your PC case contains a lot of electrical interference, which isn't altogether surprising, considering the sheer density of high-performance electronic parts all attached to each other in there. That means that audio hardware placed on the motherboard is at risk of compromising sound clarity and quality to this interference.

EVGA
NU AUDIO
SOUND
BLASTERX
PRO-GAMING

Soundcards even come with RGB lighting now—but are discrete soundcards as integral to a gaming setup as their manufacturers would have it?

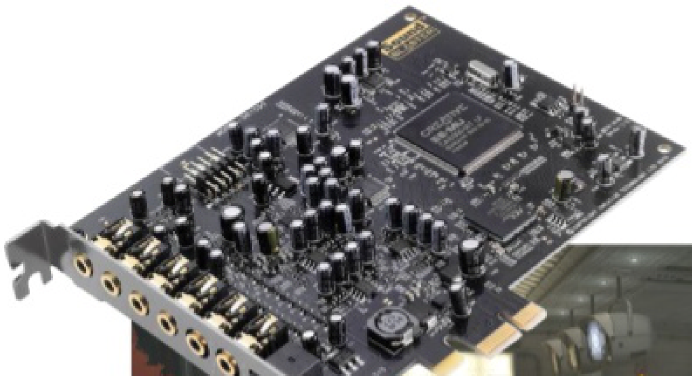
At the highest risk of electrical interference is the onboard sound chip. It's placed on the motherboard itself, where the interference is highest, so the sound quality it's able to produce is totally dependent on the quality of its shielding. That's why onboard sound modules on most modern motherboards—aside from the very cheapest—tend to have visually distinguishable covers on them. All the exterior shielding gives them the look of a little block—almost a miniature discrete soundcard that just happens to be soldered to your motherboard instead of slotted in.

So, if sound quality depends on shielding for onboard audio, the cost proposition is clear. Like the vast majority of PC circuitry, soundcards need more space as they get more powerful, to fit in all the extra processing power. Space is at a premium on motherboards, so onboard sound modules tend not to take up much real estate, and thus their processing power isn't a match for discrete cards with vastly more space. Given that they have to be shielded, too, there's further impetus from manufacturers to keep them small, and thus keep production costs down.

The result is a solution that simply does the job. Some higher end motherboards feature onboard sound with slightly higher specs and slightly flashier shielding, but in general, there's always a small amount of interference. It just isn't perceptible enough for the majority of users to notice it, or want to do anything about it.

Discrete soundcards aren't part of the mobo, so they can avoid interference more effectively—though not entirely. Perhaps most importantly, they can stretch out into that larger silicon real estate, and generate more processing power, which leads to less harmonic distortion, higher audio resolutions, and higher bitrates. They also tend to feature more in terms of inputs and outputs, so you can plug in surround sound speaker setups, and plug into a dedicated headphone slot, without having to unplug anything else. In short: They use the extra space to bump sound quality up, and signal-to-noise ratios are lower than onboard sound chips.

Finally, DACs, amps, and external devices that do both of those are excellent at avoiding electrical interference as, well, they're external. They're nowhere near all that busy hardware in your PC case, so they don't pick up the electrical noise from them. They tend to be smaller and simpler than dedicated soundcards, so the trade-off in complexity brings greater ease of use. You usually don't even need to install drivers—just plug the DAC in, plug your headphones or speakers into the DAC, and enjoy the sound.



Who still has an Audigy 2 in a box in the attic, "just in case"? Unlike GPUs, this card was an evergreen solution for years.

***Wolfenstein II: The New Colossus* is among a few recent games to ship with HD audio.**

And the truth is, for all the poring over spec sheets you can do when comparing these three audio solutions, there's no clear winner. Onboard sound is the cheapest, sounds fine to most people, and involves no setup. Dedicated soundcards offer massively bumped-up specs and usually a detectable improvement in sound quality, and DACs do that, too, but don't generally offer the same setup options. So, we're no closer to answering our original question. But let's not be disheartened—we've laid the foundations.

RICHER SOUNDS

The next step in establishing the right sound setup for you is to make sense of a soundcard's specs by plotting an audio signal's journey from PC to ear—or, indeed, from analog source to PC. There are several factors that determine overall sound quality, and they're important to acknowledge, because plugging in $10 earbuds to your PC and hitting the play button isn't going to be a transformative experience just because you splashed out on a dedicated soundcard. In other words, we need to understand the benefits of soundcard specs, such as bit depth and sample rate, before we can decide whether we'll hear the benefits.

Let's start at the source of your sound: an audio file on your PC. Your PC is a

Even the sun's interfering with your signal quality.

SIGNAL-TO-NOISE RATIOS EXPLAINED

You've seen it on audio equipment boxes and mentioned in headset reviews. You know higher is better. But what is a signal-to-noise ratio?

Expressed in decibels, it's a measurement of how much useful, clean information passes along the signal, in relation to the amount of noise, or unwanted data. So, if a soundcard promises a 100dB signal-to-noise ratio, you can expect a 100dB difference in volume between sounds you want to hear and those you don't.

To put that into context, we perceive total silence at 10dB. Conversation usually occurs at around 60dB (although, let's face it, we've all got that one friend...), and 100dB is the limit of most home and car stereos. A Formula One car revving its engine gives off about 147dB, human eardrums rupture at 195dB, and 202dB is enough to actually kill you.

So, if the useful sound in your signal is 100dB louder than the noise, it's safe to say you're not going to hear that noise until you turn things up really loud.

Why does it occur? There are two types of noise: internal and external. Internal noise pertains to the components within your system, and includes electrical noise through thermal agitation, shot noise (caused by random electron activity), and miscellaneous noise from the receiver components. External noise comes from the atmosphere, or extraterrestrial solar or cosmic interference. Don't worry, you didn't black out and start reading *UFO Conspirator Monthly,* that's just how external noise is categorized.

Additionally, anything you add to the signal chain is a potential source of noise. That includes cables and adapters, which is why the best audio setups are the neatest and simplest.

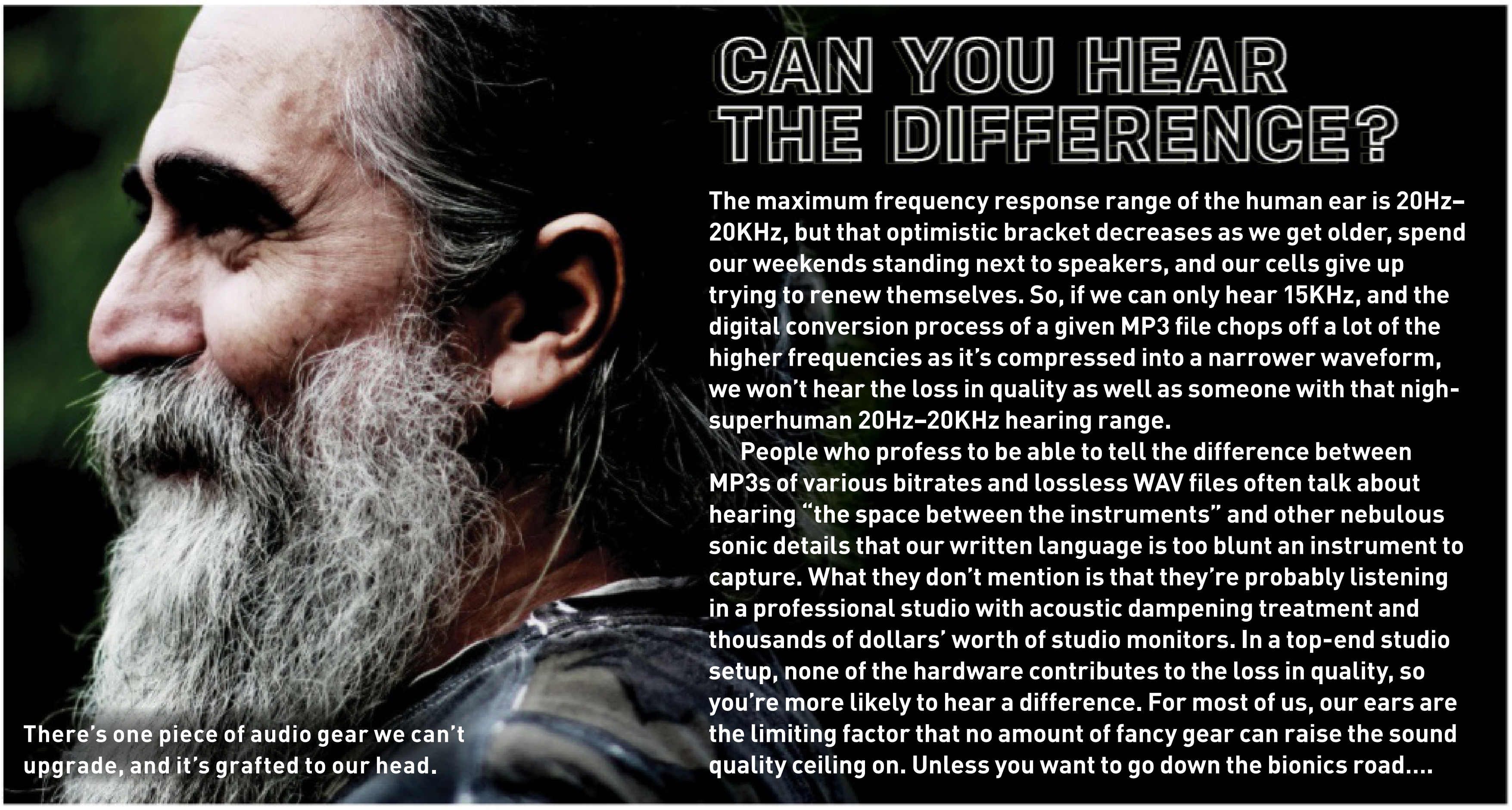
DACs have thrown a spanner in the works for soundcards: less interference, and controls where you need them.

digital device, which means it processes information by turning a set of switches on and off in order. That means when it analyzes an audio source, it has to look at it step by step, taking figurative "snapshots" of the original waveform, so it can reproduce the sound as close to identically as possible. Sample rate—in Hz—is just the rate your PC is able to capture these snapshots and play them back, and bit depth refers to the number of bits used to describe each sample; in other words, how detailed each snapshot is. Ergo, the higher your sample rate and bit depth, the closer to a perfect recreation of the original audio source you'll hear.

Want a visual representation of how a PC processes sound? Imagine the curved, oscillating line of a waveform. Recreating that is as tricky for your audio hardware as rendering a curve in a 3D environment is for your graphics card. It needs as much data as possible within the space of that curve to follow it closely. In the graphics scenario, this is your display resolution, or the number of pixels in an area. In an audio scenario, the sound resolution works in the same way—a higher resolution allows your PC to follow the curve more closely. It's still about turning the switches on or off at the fastest possible rate.

At the end of your chain, the speakers—whether within a headset or cabinet-style speaker system—have the final say on the sound's characteristics as it reaches your ear. Headphones and speakers both generally feature EQ curves, which bring out certain frequencies in order to make the overall tone richer. Conversely, studio cans and monitors are designed with as flat an EQ as possible, so you can hear how the sound actually is, rather than hearing the most flattering possible version of it. As the sound travels through the driver, and certain frequencies are either emphasized or subdued, the journey from sound source to ear is complete.

Now for the caveats. While headsets and speakers can greatly impact the



There's one piece of audio gear we can't upgrade, and it's grafted to our head.

CAN YOU HEAR THE DIFFERENCE?

The maximum frequency response range of the human ear is 20Hz–20KHz, but that optimistic bracket decreases as we get older, spend our weekends standing next to speakers, and our cells give up trying to renew themselves. So, if we can only hear 15KHz, and the digital conversion process of a given MP3 file chops off a lot of the higher frequencies as it's compressed into a narrower waveform, we won't hear the loss in quality as well as someone with that nigh-superhuman 20Hz–20KHz hearing range.

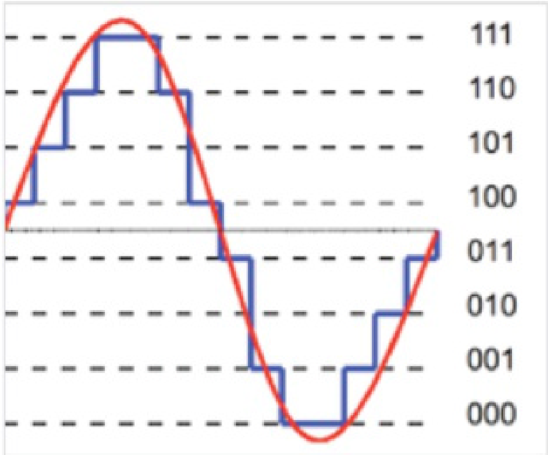
People who profess to be able to tell the difference between MP3s of various bitrates and lossless WAV files often talk about hearing "the space between the instruments" and other nebulous sonic details that our written language is too blunt an instrument to capture. What they don't mention is that they're probably listening in a professional studio with acoustic dampening treatment and thousands of dollars' worth of studio monitors. In a top-end studio setup, none of the hardware contributes to the loss in quality, so you're more likely to hear a difference. For most of us, our ears are the limiting factor that no amount of fancy gear can raise the sound quality ceiling on. Unless you want to go down the bionics road....

quality of a sound source, a soundcard, whether onboard, dedicated, or in external form, can't magically make audio sources with a low sample rate or bit depth sound better. If the source has a 96KHz sample rate, your PC's not trying to analyze a curve, but more of a blocky pyramid. Data's already been lost in the conversion process, and sound hardware can't put it back in. You just hear what's missing more accurately. And what does a 96KHz MP3 sound like? Ask anyone with an Internet connection, Napster, and some loose morals, circa 2001. It wasn't pretty.

So, you need to consider what kind of sound quality the audio sources you hear have. With gaming, most audio is compressed to accommodate smaller download sizes, so tends to max out at CD quality: 44,100Hz sample rate and 16-bit linear bit depth. Most onboard sound chips can hack those specs, so interference aside, you're not hearing a lower quality version of sound effects, dialogue, or music in the majority of games you play.

However, with the advent of HD audio—largely a marketing conceit to sell headsets with higher specs—some games, such as *Wolfenstein II: The New Colossus* and *Kingdom Come: Deliverance*, are branching out into the upper echelons. *Call of Duty's* PC releases tend to bundle in uncompressed audio, too, but it's not yet common practice for PC games to do so, and it's not used as a big marketing beat when they do.

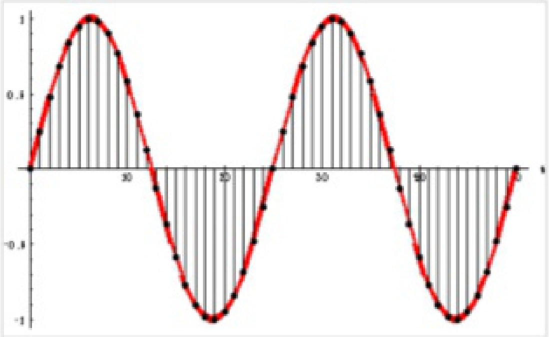
Thus, the short answer for PC users considering a sound hardware update for gaming is this: Your onboard audio is probably ample. If you're determined to spend money to treat your ears, you'll hear and feel a more obvious benefit from a headset or speaker upgrade. If you want an excuse to buy more audio gear than Quincy Jones, you need another one.



When your PC can't follow the waveform exactly, fidelity's lost. Therefore, tracking the line using as many samples as possible is key to better sound.

And here it is: If you combine a gaming habit with music, movies, and perhaps a creative endeavor, such as video or music production, discrete soundcards and external DACs are worth looking into. Not only do they noticeably improve the audio source as it journeys from your PC to your ears—particularly if you have a lossless MP3 collection or a subscription to a high-res streaming service—they also improve sound quality in the other direction.

Just like the audio source journey mentioned earlier, the same principles apply when the audio source begins in the real world, picked up as an analog sound signal by a microphone, and is converted into a digital signal by sound hardware. Sample rate and bit depth are king here: The higher your system can capture the sound, the more accurately it can represent it digitally as a recording. This is of paramount importance when you're putting together a home recording studio setup—onboard sound isn't going to cut it.



The benefits of a high sample rate: Capturing a data image more frequently produces a more faithful waveform to the original source.

Because if you're recording a vocal track using a microphone, and capturing that recording at 44,100Hz and 16-bit, you've set the ceiling for that audio file's sound quality. It can never be better than the CD-quality recording you created, no matter how it's mastered, or which speakers it's played through. Given that audio-to-digital conversion almost always involves some loss of data, it's a better idea to set the initial sound quality ceiling high, and worry about how lossy your exported

Those with a musical bent don't just need a discrete soundcard—they need a complete home studio setup.

SU-SU-STUDIO

If you're serious about music production, you're in the market for an entirely different kind of soundcard. There's a world of professional audio external soundcards out there, but key to figuring out which one to go for is working out the number of inputs you need.

If you plan to record several instruments at once—perhaps via mic'ed up amplifiers in addition to direct input—the more the better. Having a couple of XLR and stereo jack inputs would prove particularly handy if you're recording in this way, and the same goes for capturing vocals on a microphone at the same time as an instrument via DI or MIDI.

However, if you simply want to capture one performance at a time, a small and affordable soundcard, such as the Scarlett Studio Solo, featuring one XLR and one instrument input, is ample.

In this hardware field, manufacturers pay particular attention to input latency as well as signal-to-noise ratio, so you can perform your parts with confidence, and hear them back just as you performed them. Options such as monitoring level and phantom power for mics are also essential, and generally aren't found in enthusiast discrete soundcards. Will they also improve your gaming experience, or the quality of music and movies you listen to? Yes they will. Although they're not designed to exaggerate sounds or dress them up for your ears, pro audio soundcards feature sky-high sample rates and bit depths in order to record at the highest fidelity, and that means they'll bring the best out of the audio you want to experience, not just the audio you want to create.

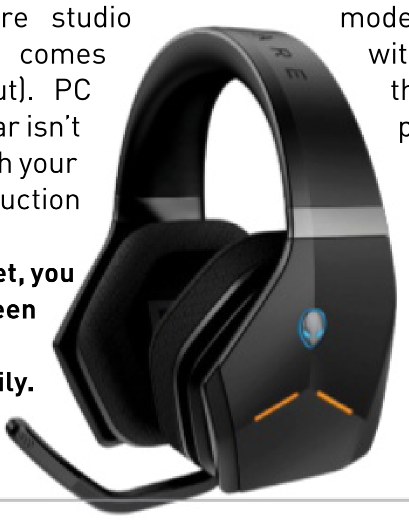
So why not just use one of these as an all-in-one solution? Well, they're expensive if you're not going to use their recording features—a DAC would do just the same for less.

mixdowns are getting further down the line. It's in this regard that the quality of your connections comes into play, too. Generally, 3.5mm connections don't take mic or instrument inputs natively, so you need to add an XLR or instrument jack adapter to the signal chain, which increases the chance of introducing hiss, pops, scratchy sounds, and a dirtier signal. This is where studio recording equipment comes into play (see boxout). PC enthusiast market gear isn't going to help you reach your audio or video production goals as well as bespoke gear will. A Creative Sound Blaster might make your games sound better, but Fleetwood Mac didn't record *Rumours* with one.

That means the discrete soundcard is really best for the gamer and multimedia aficionado who doesn't have production aspirations. You can easily connect a 5.1 or 7.1 surround speaker system into most models, and they're generally supplied with bespoke software programs that allow custom EQ tweaking and profile creation for different usage scenarios. You'll appreciate the increased sound quality when you do play games featuring HD audio, and you'll make the most of music and video files featuring higher bitrates and audio resolutions. It won't necessarily make you a better gamer, but it'll probably make you a happier one.

That leaves external DACs. Many DACs contain an amp that boosts the signal higher, so if your headphones are low impedance, you get a nice rich volume boost without introducing extra harmonic distortion as the signal increases. They're also incredibly simple and space-economical to setup, so there's a lot to love there. However, they're generally intended for headsets, rather than multi-unit speaker systems.

The ultimate solution, then? Totally dependent on your exact needs. While most PC enthusiasts don't need a soundcard, they're essential to content creators and producers. Even if you don't fit into that category, almost everyone would enjoy the benefits on some level.



With a high-end headset, you hear differences between onboard and discrete soundcards more readily.

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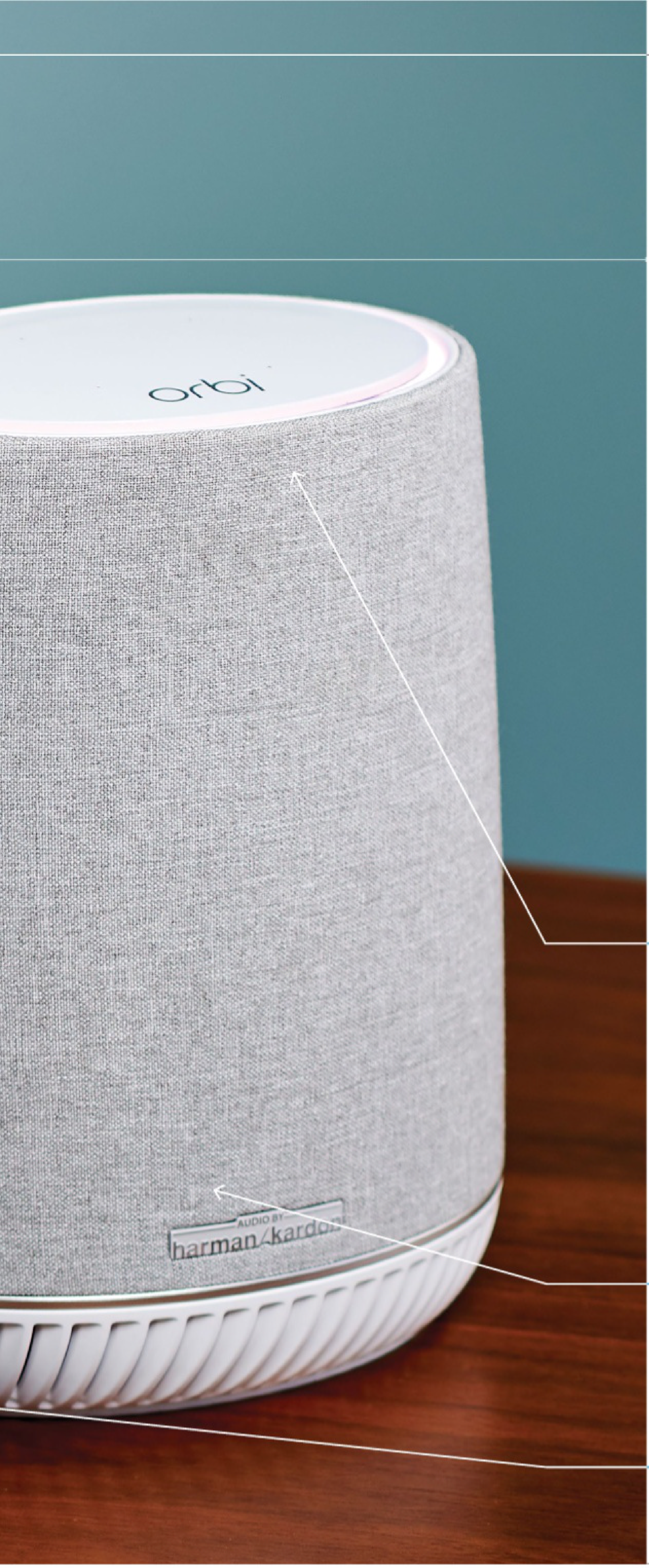


Netgear Orbi Voice RBK50V

WE'RE STILL A BIT SCARED OF ALEXA. The ubiquitous presence of digital assistants in our homes, offices, and cars feels faintly threatening, whether it's Siri, Google, or Amazon's own offering. Nonetheless, it's hard to deny how helpful they are, and ordering your speaker to play your favorite jams does resonate with futuristic delight. Enter Netgear's newest offering: the Orbi Voice, a two-part design that includes a high-end router and smart speaker.

The Orbi is chunkier than some other home assistant options, at almost nine inches tall and six inches wide. It's fairly weighty, too. Next to the Alexa-toting Amazon Echo Dot, it looks like a monster. But that extra size has enabled Netgear to shove more funky tech inside, and its sound quality equals that of the best smart speakers. Tri-band mesh Wi-Fi antennas mean that moving between rooms causes minimal signal disruption, even while streaming.

The router is the slimmer tower, with solid plastic sides, while the speaker is beefier, coated in high-quality fabric. Setting up is a cinch, with easy-access sync buttons on the rear of each unit. Alexa comes ready to roll, and the Orbi also supports Disney's Circle program, enabling direct management of devices on the network—perfect for keeping the kids off a TV binge. **–CHRISTIAN GUYTON**

1 LISTENING IN

At the top, four mics with far-field voice recognition support are visible as tiny holes. Alexa learns as it listens, adapting to your voice to better carry out commands. Just don't joke about ordering 10,000 Nerf guns on Amazon.

2 SOUND BARRIER

Concealed inside the Orbi Voice's low-key exterior lie a 3.5-inch woofer, 1-inch tweeter, and a bass reflex port. With audio courtesy of Harman Kardon, the sound this unit pumps out is impressive, capable of covering up to 300m^2 of space.

3 HAPPY WI-FI, HAPPY LIFE

The Orbi's two units act as both a router and extender, with FastLane3 tech beaming directly from the router to the speaker. The Orbi has a single Wi-Fi SSD-ID, and delivers a signal capable of covering even the largest of homes.

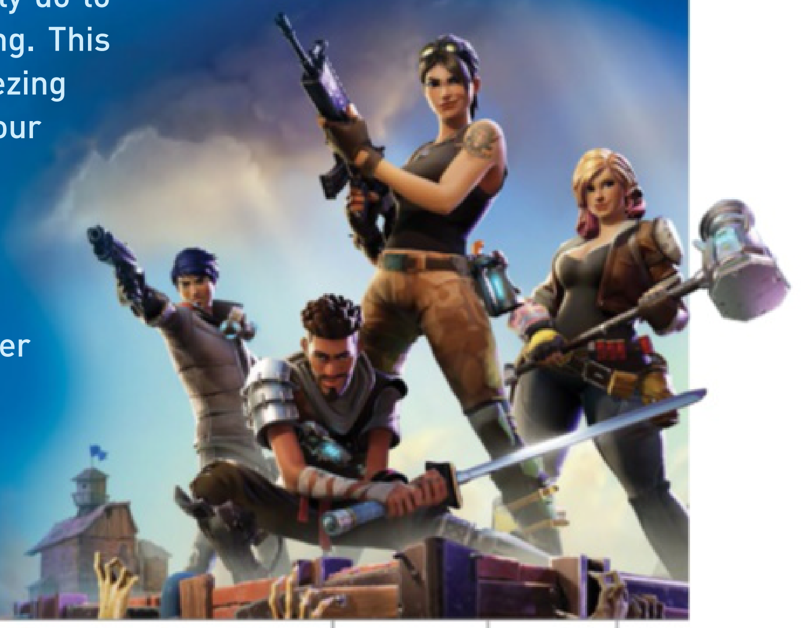
MAXIMUS XI
EXTREME
CPU
Castrol EDGE
KYB

WHAT MAKES A GAMING MOTHERBOARD?

Chris Lloyd reveals what really matters when it comes to enthusiast class hardware

Gaming PCs emerged in the 1980s (their specifications would make you laugh now); by the 2000s, custom-built gaming machines were everywhere; and now you can buy just about everything you need off the shelf, from colored cables to whole systems swathed in lights. Tinkering with multipliers and clock frequencies has gone mainstream.

If you're putting together a gaming rig, you'll want a gaming motherboard—obvious, right? But are these motherboards really worth it? What can a gaming motherboard actually do to improve gaming? In a word: overclocking. This is really what they are all about, squeezing every ounce of performance from your processor and subsystems. You know how this goes: You need a big cooler, an unlocked processor, and the right motherboard chipset. But getting the right motherboard to tie these together can make all the difference....



Reliable overclocking is all about supplying stable voltages, and keeping cool while doing so. This is where the motherboard's voltage regulator modules (VRMs) swing into action, stepping down the voltage from your PSU (usually from the 12V rail) into the low voltage you want for the processor core, typically 1.3V or so. All boards have them, but gamer boards have fancy ones.

A good clean signal is key, with no peaks and troughs. As you approach the limits of the CPU capabilities, these spoil the fun, particularly the voltage "droops." The VRM has four main parts: capacitors, chokes (inductors), metal oxide semiconductor field-effect transistors (MOSFETs), and a controller (a pulse width modulation chip).

The VRM system is regulated by the PWM controller sending control signals via drivers for each phase (the driver ICs are often incorporated into the MOSFET chips). Very simply put, the input from your PSU is fed into the MOSFETs, then out through an arrangement of chokes and capacitors, until a smooth low voltage is delivered to your chip.

The capacitors are passive devices that help smooth out a signal. The best are Japanese, or so popular belief has it. In the great "capacitor plague" between 1999 and 2007, boatloads of Chinese and Taiwanese capacitors leaked and blew, costing big-name manufacturers hundreds of millions in trashed systems. The problems have long since been sorted, but the stain lives on. Japanese manufacturers do tend to have high standards, but they are not alone.

Capacitors are often quoted with a "K" rating, such as 10K. This is the lifespan of the capacitor, so a 10K capacitor should last for 10,000 hours. Yes, that's not even 14 months if your system is permanently switched on. This lifespan rating is measured at an operating temperature of 105 C, which it shouldn't reach unless you've not got the cooling sorted out.

Capacitors last a lot longer at lower temperatures, doubling for every drop of 10 C or so. They also last longer under low loads. You can expect a capacitor to last four to ten or more times as long as the lifespan rating if it's not misused. Capacitors don't just stop working either (barring a leak); the performance simply starts to drop off. 12K caps are nice, but no reason to pick one board over another.

More important is the ripple current tolerance, rated in mArms (milliampere root mean square), the higher the better, toward 5,000mArms being good going, and 2–3,000mArms average. High capacitance also helps handle high loads. This is measured in microfarads; over 1,000uF is chunky, 600uF or under less so. Going over spec helps keep the strain down, as capacitors run more efficiently under lower loads. Different designs wire capacitors differently, some going for a few large ones, other VRMs run smaller ones in parallel, and exact details can be hard to dig up, so working out if it's a good setup is something of a dark art.

The chokes are fundamental to lowering voltage. All chokes are inductors, but not all inductors are chokes. Inductors resist changes in voltage due to the magnetic field they develop, handily without producing much heat. Look out for super ferrite chokes, SFCs, or variations on alloy chokes. Fancy materials here are good.

HOT TOPIC

Then we get to the heart of the VRM, and the part that does the heavy lifting: the MOSFETs. These are essentially switches. You should find them tucked away under a heatsink. The hotter a MOSFET gets, the more it affects the resistance, and efficiency drops, until you hit an never-ending loop that ends in something nasty.

In a nutshell, these work by rapidly switching a current on and off using the control signal from the PWM chip, the frequency of which sets the output voltage. Using a single circuit would lead to a rather jagged signal, and put all the power through one chip, so the VRM runs a number of circuits in parallel. Each separate system is called a phase, and has two MOSFETs (or should have), and a choke. The chokes are charged until the desired voltage is reached, then discharged in sequence.

Each phase supplies part of signal, and spreading the load across circuits helps keep heat down, and enables a much smoother voltage, as each phase is offset. As a rule of thumb, the more phases the better. VRM phases are quoted as a number, such as 8+2. The first number is the number of phases for the CPU, the second number is those reserved for the memory. PWM chips in modern motherboards typically have four, six, eight, or 10 phases. So, how can some boast of having more?

Some boards use a "doubler," an IC that splits a signal into two interleaved signals, halving the switching frequency. They help keep temperatures down by spreading the load, but add little to voltage ripple suppression. It's a neat solution for high-power outputs, but does mean that a VRM advertised as eight-phase may actually be a doubled four-phase. If you see a board with 24 phases, you know it's not all true separate phases. Other tricks include using fewer MOSFETs, doubling the load on some, but still counting it as a full eight-phase board. Sneaky.

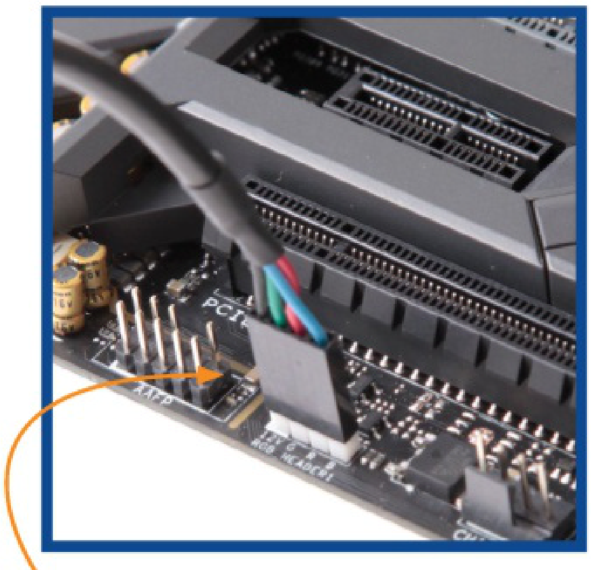
Some budget boards also use parallel wiring, where one phase signal is used to drive two circuits. Again, it means cooler running for the same power, but without any extra smoothing effect. Sometimes this is advertised as two phases, only it really isn't. The output voltage is checked on every phase, so for the tightest control, you want as many "true" phases as possible. Manufacturers use the bigger numbers to sell better.

Overheating kills VRMs. Gaming mobos have heatsinks. Sometimes they're just blocks of aluminum. Some cover the heatsink in a plastic shroud, which may look cool, but doesn't help get air around them. Ideally, you want a finned or slotted copper heatsink; adding heatpipes is even better. A thermal sensor so you can keep an eye on temperatures helps, too.

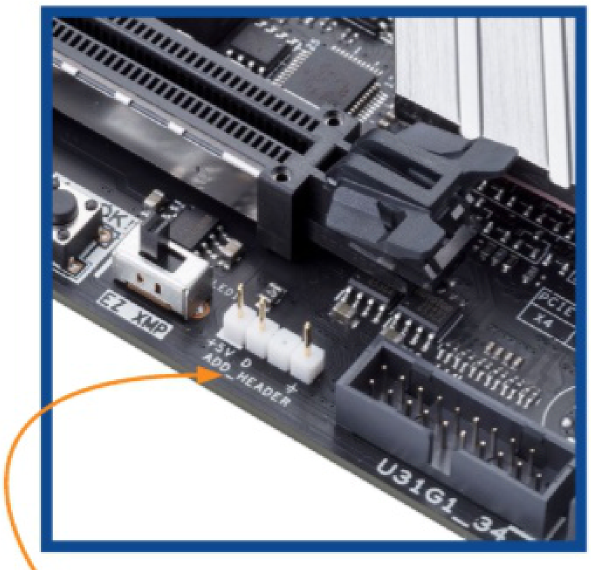
You'll also want to pair the board with a decent power supply, so your board has a good steady voltage to work with in the first place. Look for low levels of voltage ripple, measured in mV—a good PSU can manage under 30mV, while a top-notch design can manage under 10mV.

Gaming boards tend to be overclocking boards, and the quality of the VRM system is important. A poor one means you can't make the most of that unlocked processor, and a good one means you can wring its neck, and keep it stable. Don't get blinded by a high phase count; eight true phases, doubled perhaps to keep things cool, is

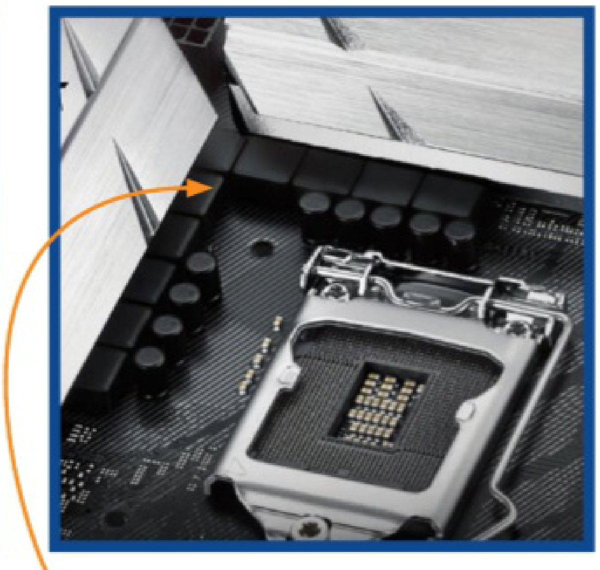
> **THERE IS ONE THING GAMING BOARDS DO THAT MORE UTILITARIAN ONES DON'T: THEY LOOK COOL.**



A 12V RGB header and cable, helpfully color-coded. More powerful than the newer 5V ARGB lights, but not as funky.

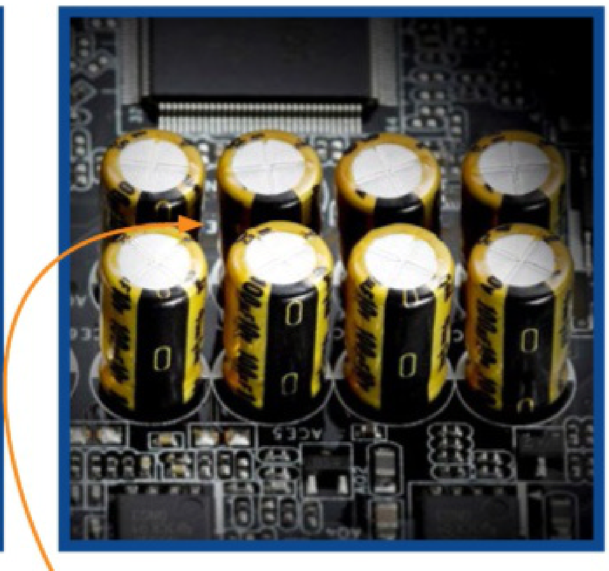


A 5V addressable RGB header, where every LED is digitally controlled. It uses the same basic block as older four-pin headers.



The chunky VRM. Closest to the socket are the capacitors, behind them are chokes, and under the heatsinks are the MOSFETs.

This is a gaming system, we know that because it has a lot of RGB lights. Nice, but not really the point.



Capacitors—no, they don't have to be Japanese, and a 10K rated capacitor will last years under the right conditions.

The sound subsystem, shielded from interference, and with its own set of capacitors to smooth out wrinkles.

preferable. Then look to the component quality and cooling arrangements.

If you're fiddling with the base clock, you need RAM that can cope. There's a lot of hot air talked about memory speed; it's closely linked to processor speed, so trying to go beyond that often yields little, or throws the timing sequences out. Generally, more or better quality RAM is better than ever-so slightly faster RAM.

ADDED EXTRAS

The I/O systems in a gaming board are similar to any other board. Sound systems are generally beefier, and, of course, we have the RGB lights. You also need plenty of PWM fan headers; at least two or three, preferably more. These are cheap to add, so manufacturers tend to be generous. If you fancy water cooling, you'll find dedicated pump headers on many boards, too. Some also have hybrid fan headers, which can run fans or water pumps, sensing which is connected, and with extra pins for a temperature sensor. Smart fans offer custom profiles, switching fans off below certain temperatures, and starting them up in configurable patterns.

What else to look for? Pretty much the same sort of things as a standard motherboard, only often more of them. Gaming boards are sold as premium gear, and manufacturers throw their best stuff at the high-end versions; many have multiple USB-C, USB 3.1 Gen 2, and dual BIOS configurations (which can come in very handy when fiddling with settings).

Gaming boards also tend to be put together well. The graphics card slots are reinforced, or "armored," to support those heavy cards. Memory slots are often more sturdy, too—these boards tend to have hardware removed and fitted more often than your average office machine. Cooling gets the attention it deserves. They're aimed at enthusiasts, not accountants, so there's a healthy rivalry between makers to offer something enticing.

There is one thing gaming boards do that their more utilitarian brethren do not: They look cool. A gaming rig is a statement piece as well as functional. Much of this is mere frippery—there are some fanciful designs that add nothing to practicality—but that's not the point. If it's on show, you may as well make a show.

GAMING OR GENERIC?

So, are they worth it? Gaming mobos can come at a premium, and underneath, much of it is the same as any other board. However, that premium has evaporated over the last few years (partially due to the price of standard motherboards increasing), to the point where it's hard to save more than $35 or so by getting the most dull and generic motherboard you can find instead. If you are running chips at stock speeds, and you've no interest in a battery of fancy lights, you might be able to shave a few bucks off your build. For the rest of us, it is the only way to go.

Getting into overclocking comes a little cheaper with AMD, who is more generous with its chips: All Ryzen chips are unlocked, unlike Intel, which locks most down. A solid budget gaming board comes in at around $90, so there's no reason not to tweak if your chip will co-operate. The budget boards tend to be one of the smaller form factors, which can lead to things being squashed together, and you lose out on some slots.

Moving up the market can start to get more interesting—double your budget, and the choice is huge, and you get a decent set of SATA ports, PCIe, and M.2 slots. We enter the world of diminishing returns, though; as you move to the $300-plus boards, the potential overclocking returns get slimmer and slimmer. However, if you've dropped over $500 on a processor, it makes sense to give it the board it deserves.

The top boards have impressive feature lists, boasting of this and that, and some of your hard earned will be buying cosmetic features: fancy moldings, etchings, and cast parts, and some of the "features" are pure fluff (3D printable cable shrouds, anyone?). Where you want the real attention spent is on that VRM—it's this that will make your overclocking pay off, and get the best from your rig. Look for features that improve this, such as multiple thermal sensors, good solid heatsinks, and lots of fan headers first, over the cosmetic.

Overclocking isn't the fearsome proposition it used to be; these boards make it simple, from the BIOS through to the memory sub-circuits. Gaming boards have come a long way in the last few years, and the best of them give you all you need for awesomeness, with lights on.

HOW MANY LANES?

There is a limit of your SATA, USB, M.2, and PCIe lanes that isn't obvious. It's defined by the processor and chipset combination, which has a fixed number of High Speed Input/Output lanes, equivalent to PCIe lanes. It is partly down to the mobo designers how these lines are wired, so what you get isn't standardized, or quite what it seems.

Intel's Z390, Z370, or H370 have 30 HSIO lanes. Your CPU, assuming you're not running an X-series monster, supplies 16 more. The CPU lanes go direct to the main graphics card; on a gaming board, they run to two suitably spaced x16 PCIe slots, so if you run a two-card rig, each gets a x8 from the CPU. Ryzen chips have 20 spare lanes, so the right board can also run an M.2 card from the processor lanes.

Everything else hangs off the mobo chipset. A fully wired M.2 slot needs four lanes, a SATA drive needs two, USB needs one. To add flexibility, some PCIe lanes are switched, running one thing or another. So if you plug in everything possible, some things won't work. A block of lanes may be wired to a pair of SATA drives or an M.2 card, but not both.

What is shared with what often isn't clear, and can require some research; look at online manuals for details. If you plan to add multiple M.2 cards, or a RAID system, you need to check everything will run. Things are less restrictive on HEDT systems; here you have lanes to spare for triple or quad graphics cards, and can get multiple M.2 cards on to the processor side of the action. Gaming boards are designed for those after speed, so M.2 and multiple PCIe are the order of the day. Plan for expansion, and get as much solid state as you can.

REPUBLIC OF GAMERS
SUPREMEFX

SOUNDING OUT SOUND

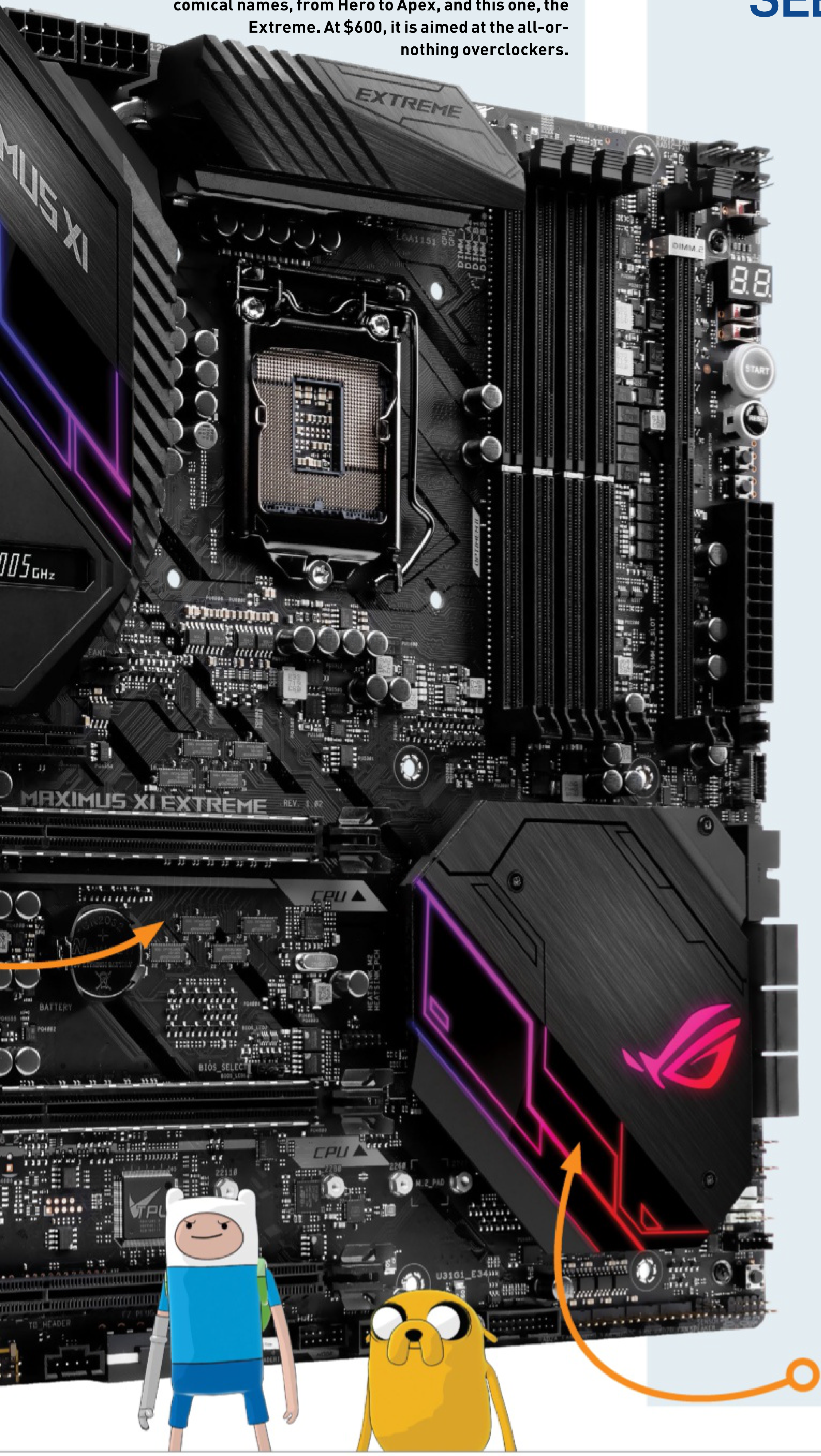
Nearly all motherboards have on-board sound; long gone are the days when you had to add a dedicated soundcard. Even the most basic board produces pretty decent sound, too, although not according to the people who make soundcards. Gaming boards often boast of high-end sound systems, but are they worth it?

The killer for sound quality is interference; anybody involved in high-end audio will take one look inside a PC and shudder. It is simply the wrong place for proper high-end audio. Some decent EMI shielding, high-quality capacitors, and carefully arranged components go some way to improve things—that's what to look for first.

After that, you're on a difficult path. Many mobos boast about the swish sound chips fitted—Realtek ALC1150 or ALC1220s, for example. These need to be paired with a decent on-board amplifier. Look for high signal-to-noise ratios; you want 110dB or more for a properly clean sound.

High-end audio requires decent speakers to appreciate. There is no point picking a board because of its sound system if you are going to listen to it on a battered pair of basic cans. Your money will go further here than anywhere else. If you do stretch to high-impedance headphones, you'll need an on-board amp that can deliver enough power, or it'll all be a bit quiet.

The better boards do come with pretty fancy sound hardware, and unless you are planning to run a full 7.1 system in a controlled environment to listen to harmonically diverse music, they'll serve you well. Certainly well enough for gaming, where compressed 16-bit samples are the order of the day. Going beyond this means moving to a external soundcard, which is a whole different world.


Asus's ROG Maximus XI range of boards all have almost comical names, from Hero to Apex, and this one, the Extreme. At $600, it is aimed at the all-or-nothing overclockers.

SEEING THE LIGHT

What's a fancy gaming rig without a multitude of RGB lights? Many boards come with a plethora of lights, but with RGB headers, you can really go to town with extra lighting strips.

The four-pin RGB header has individual pins for the three colors, enabling each to be fired as required, and a common ground. This came over from domestic RGB lighting. Gigabyte has used a five-pin header, which has an extra pin for dedicated white LEDs. Four-pin systems run at 12V, and are essentially analog; variable voltages give 256 levels for each color, but all LEDs of that color on a strip fire at once.

Then came addressable RGB headers—ARGB—which are three-pin: power, ground, and a control line. These run at 5V, and are digitally controlled, so they can address each LED on a strip individually—far funkier effects. The lower voltage does mean you can't power a long strip; no 10-feet affairs wrapped around your desk, for example. It's good for about two feet.

The pin spacing is the same, so it is possible to plug the "wrong" sort into the header (assuming the ARGB plug hasn't got a blanked-off pin), or use an adapter. However, plugging a strip expecting 5V into a 12V header may well cause it to pop—luckily, lighting strips come pretty cheap.

All the big board manufacturers have their own brand of RGB control systems: Asus has Aura, Gigabyte has RGB Fusion, and MSI has Mystic Light Sync. All have similar party tricks—dividing your lights into "zones," and applying configurable lighting effects, including pulsing along to sounds, or even indicating your processor's temperature. Compatible ARGB components, such as graphics cards and fans, can join in, too.

Frankly, the RGB lighting capabilities of a potential gaming board shouldn't rank high on your list of considerations; they're just a nice extra. Decent boards have a pair of ARGB headers minimum; some carry half a dozen. If you want more, you can always add a dedicated controller, such as the NZXT Hue 2 (four channels and strips for $80). There are also budget systems from around $20, or you can add a powered adapter that splits out a single RGB header into multiples, so you can festoon everything with lights. Why not?

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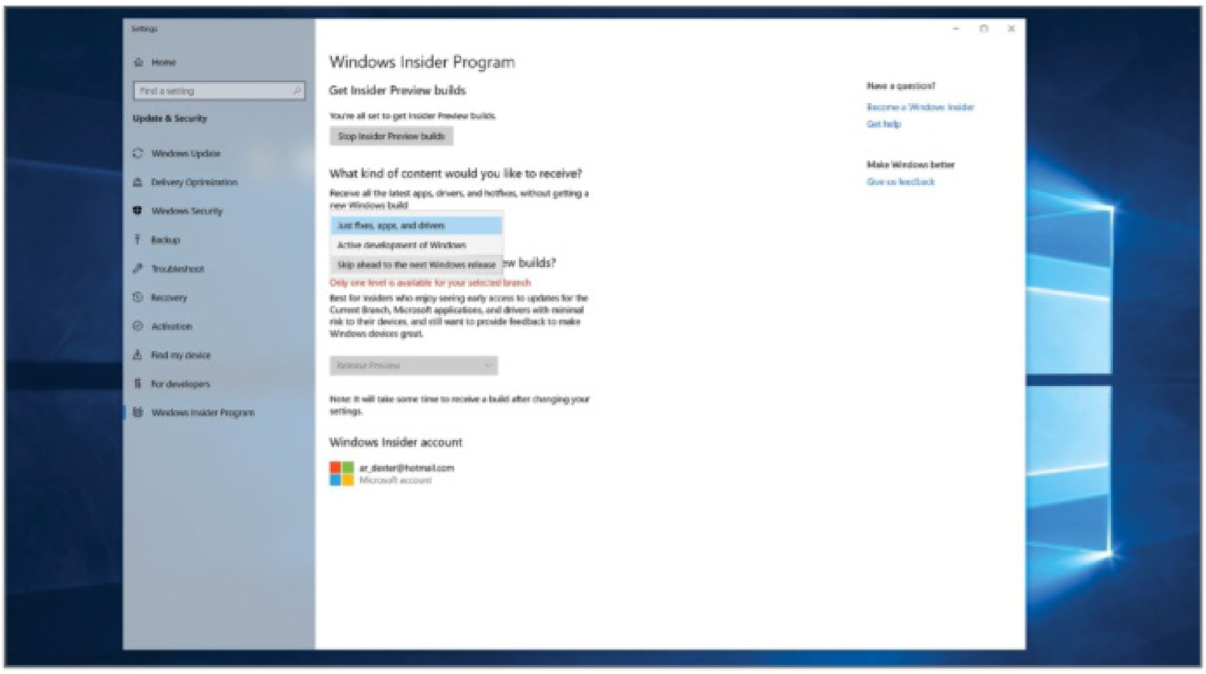
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH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Delivery Optimization
Windows Security
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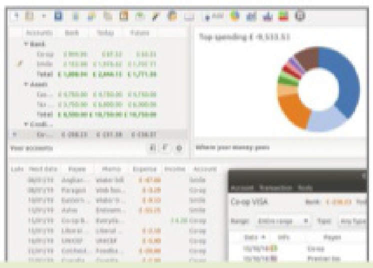
Microsoft account

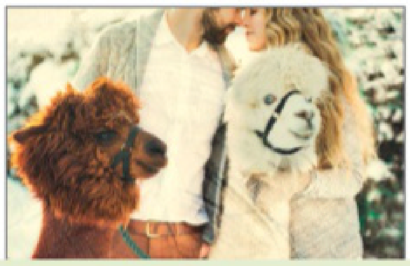
ACCESS PREVIEW BUILDS

Struggling with Windows updates? Welcome to the club. Our executive editor recently had his rig inform him that the (clearly installed) GPU was non-existent. Windows updating had left it catatonic, but a trip to “Update and Security” under “Settings” reveals options for the Insider Program; electing to download “Just fixes, apps, and drivers” sorted out his problem, so he could return to “Active development of Windows.”

MAKE – USE – CREATE



58
Track your personal finances with ease



66
Make textured paint effects in Luminar 3

68
The new face in the office builds his own computer

CHRISTIAN GUYTON
STAFF WRITER

NEW FACE, NEW PLACE

Darn, it’s weird seeing my picture up there. After a few years of freelancing, I’m settling down here at *Maximum PC*. It’s been fun to play the field as a high-class journalistic prostitute, but all good things must come to an end.

It’s nice to have your name on something, and I’m looking forward to cracking on with bigger and more exciting projects here. As a born-and-raised gamer, starting off with a game-related “Head to Head” (pg. 20) was a satisfying prospect, but first I needed a rig to play those games. Our former deputy editor Zak might have dunked on the RTX 2060 a couple of months previously in this very column, but that didn’t stop me from snatching it up for my build—whether I’ll be able to keep it is another matter.

Speaking of Zak, he’ll be pleased to hear that I’m going to keep railing against the onslaught of garish RGB lightstrips. The hill I’ll die on is that computers should run fast and quiet. Flashy, over-the-top cases brimming with LEDs and internal rainbow lighting should always be secondary to the actual power of your PC.

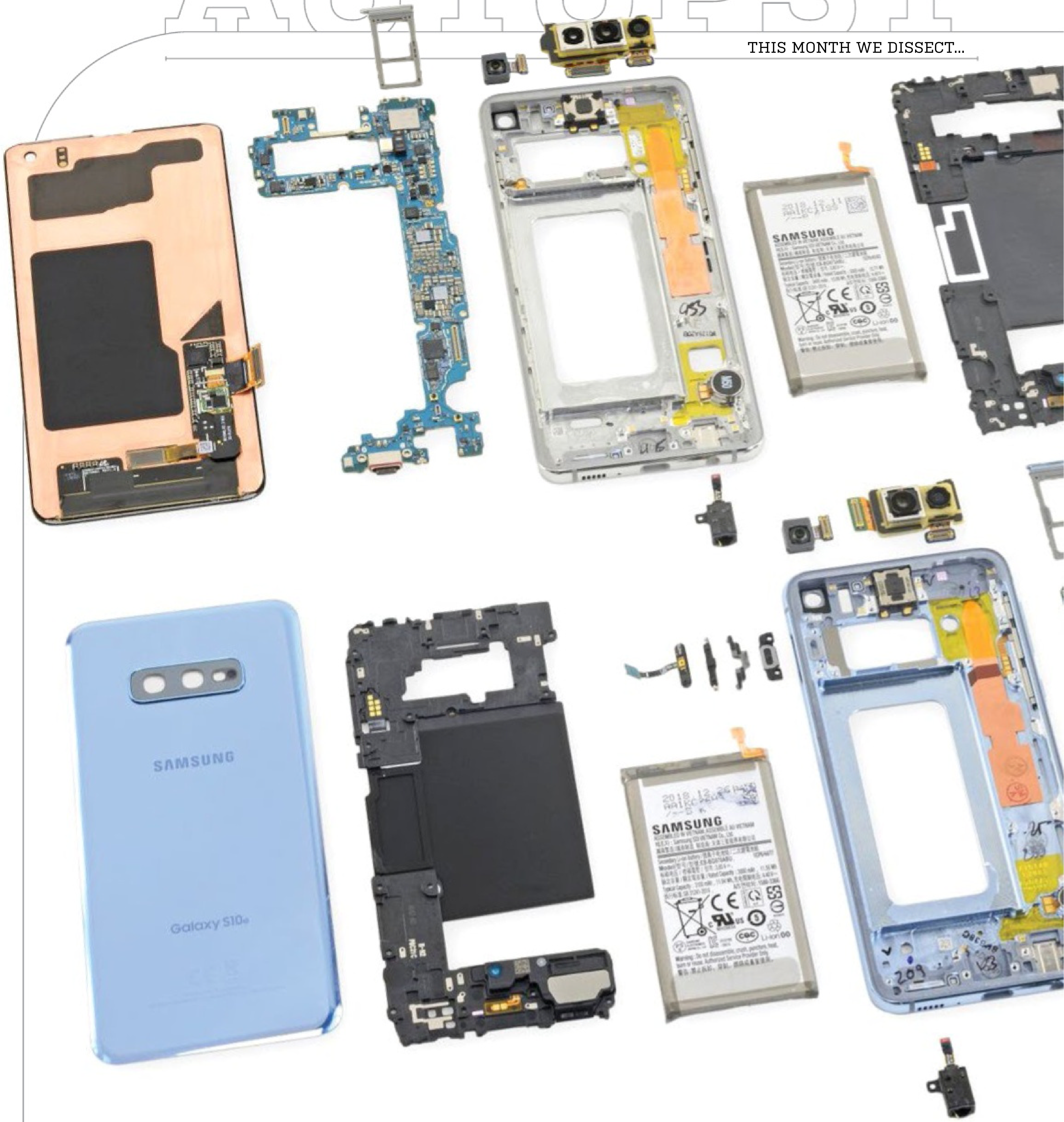
Now, if you’ll excuse me, I’m off to boot up *Warframe* on my new build, and set the particle settings to “Ludicrous.”

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT
presents:

AUTOPSY

THIS MONTH WE DISSECT...


SAMSUNG
SAMSUNG
SAMSUNG
Galaxy S10e

Samsung S10 & S10e

BACKGROUND

After the iPhone's sudden foray into Roman numerals, we half expected Samsung to give us a Galaxy SX. But here we are, with the all-too-predictably-named S10 and S10e. Are they really as plain as their names suggest? Only one way to find out—time for a teardown!

MAJOR TECH SPECS

- Super AMOLED Infinity-O displays: 5.8-inch (2280×1080) on the S10e; 6.1-inch (3040×1440) on the S10
- Qualcomm Snapdragon 855 processor
- 10-megapixel selfie camera and a rear-facing camera, with one dual-aperture 12MP wide-angle module, and one 16MP ultra-wide module
- A conventional fingerprint sensor in the S10e's side button versus the new ultrasonic fingerprint sensor hidden under the S10's display
- Headphone jack, USB-C port, and microSD card slot
- IP68 water/dust-resistance rating

KEY FINDINGS

- These phones' monolithic facades don't reveal much, but we note the curved display edges on the S10 and the ceramic back cover. While they sport similar exteriors, the budget-friendly S10e gets a bigger power button, where its capacitive fingerprint sensor is housed. The S10 has a sensor you can't even see... without a teardown, that is.
- We pull the backs off our phones, waiting for some kind of trap. Not this time! The panels come right off. We notice heat-dissipating graphite pads strategically placed on these back covers. Something in here is designed to get hot without burning your fingers.
- Just a few standard Phillips screws between us and the good stuff. We execute a flawless motherboard lift—and unfortunately the USB-C port comes along for the ride. One of the Galaxy phones' few positive repair points—a modular, replaceable USB-C port—is gone.
- Taking a peek beneath the motherboard, the copper heat pipe is beefier than the one in the S9. Meanwhile, we peel off a piece of thermal interface material from the board. All that copper makes a great surface thermal transfer, but you need this interface to fill in any gaps.
- Next we pop the main camera array off the board; it comes encased in a yellow plastic frame. Battery time! These are heavily adhered to their metal frames, with no friendly pull tabs in sight. These portable power plants are rocking 11.94Wh for the S10e and 13.09Wh for the S10. In comparison, the competing iPhone XR sports 11.16Wh.
- We take our chances removing the delicate displays. Inside the S10, we spot the new ultrasonic fingerprint-sensing getup. The flat display on the S10e is barely less scary to remove than the curved S10 screen. Sadly, neither will live to play another game of *Fortnite*. Assume you're going to pay an arm and a leg for a new screen.
- Repairability score: 3 out of 10 (10 is easiest to repair). A single Phillips driver takes care of all the screws. Many components can be replaced independently, but the charging port is now soldered to the main board. Battery replacement is possible, but difficult. Glued-down glass both front and back means greater risk of breakage. Screen repairs require a lot of disassembly. ⏻

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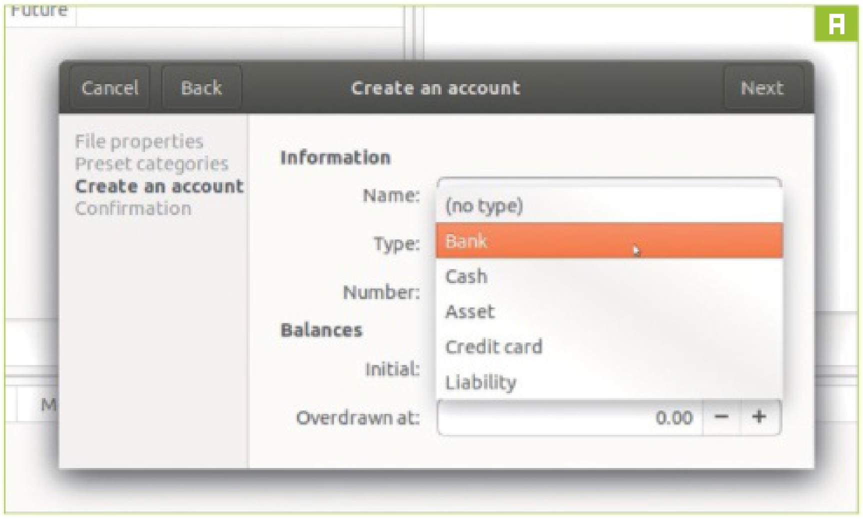


1 GET THE SOFTWARE

HomeBank for Windows can be downloaded from http://homebank.free.fr/en/; if you're running Ubuntu Linux, open a Terminal window (press Ctrl-Alt-T), then type the following:

```
$ sudo add-apt-repository ppa:mdoyen/homebank
$ sudo apt-get update
$ sudo apt-get install homebank
```

›› Once installed, launch HomeBank, and a welcome dialog appears, providing a convenient link to the manual, which is also accessible online at http://homebank.free.fr/help/index.html.

HOW DATA IS BROKEN DOWN

HomeBank records your finances through several layers of data. At the top is your main file, or "wallet," as HomeBank describes it. Beneath this is the account level, where you can store multiple accounts—current, savings, credit card, and even loans and mortgages. The final, bottom layer is transactions, which are attached to specific accounts.

Each transaction is assigned a specific type of payment, from credit or debit card, electronic payment, and direct debit or standing order to deposit, cash, financial fee (for example, a non-dollar payment charge when paying for goods in a foreign currency), and transfer between accounts. Choose "Internal transfer" if you wish to move money from one account in HomeBank (savings, for instance) to another (your current account, or perhaps your credit card, when paying the bill).

Transactions are also assigned to categories, which help you track specific spending. These are user-definable, and you can split a single payment or deposit between multiple categories. You can also manage transactions using keyword tags and the memo, which enables you to record a description. You also record the "payee," the person or institution you're paying (or receiving money from). All these fields can also be used to track certain types of spending later.

2 WORK THROUGH THE WIZARD

Start by creating a new file. You'll run through a quick-fire wizard—step one is to verify the file owner (your username by default, but it can be anything) and currency, which should be your native one. Click "Change" to switch if necessary. Click "Next." Verify the correct language and preset file ("en" for English) are selected—these are the categories you assign transactions to, and can be edited. Click "Next" again.

›› Then you're asked to create an account [**Image A**]. Each HomeBank file—or wallet—can store multiple accounts, so start with your first account. Give it a suitable name—your bank, say—and assign it a specific type: "bank"—think current account, cash, asset, such as savings or pension, credit card, or liability, for example, mortgage or personal loan.

›› If you wish, enter your account number in the "Number" field. You're now prompted to set the initial balance. This is effectively the point at which you start monitoring the account. You could begin with the closing balance of your last statement, but we suggest choosing an arbitrary date up to three months ago, and starting from there. Diligently entering transactions from your statements helps you familiarize yourself with HomeBank's interface.

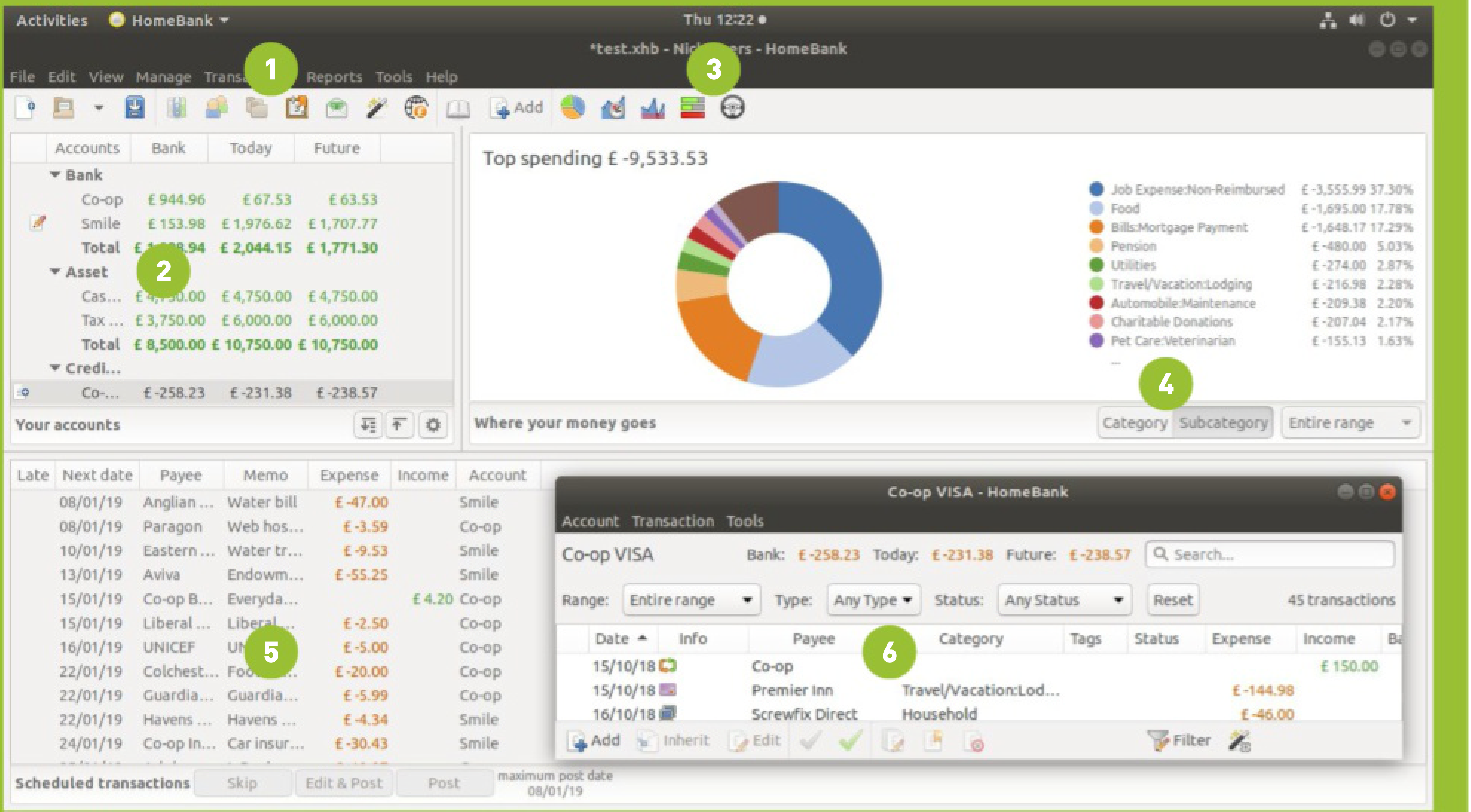
›› The final figure—"Overdrawn at"—should be left zero, unless you have an interest-free overdraft facility, in which case enter that. Click "Next → Apply." Note, you can change this information at any time via "Manage → Accounts," where you'll also find space for additional information, such as the checkbook number to start counting forward from. This is also where you go to create all the other accounts you wish to track.

3 IT'S A TRANSACTION!

HomeBank now takes you to its main screen, split into three panes. More on this later—for now, choose "File → Save" to save your file for the first time. Once done, double-click your account in the main window, and you'll see a new account window pop up, which is where that account's transactions will be displayed.

›› To enter your first transaction, click the "Add" button in the bottom-left. A pop-up dialog reveals what you can record about the transaction. Today's date is selected by default, but you can choose a different one. The "Amount" field is critical—you need to make sure

FEEL AT HOME WITH HOMEBANK



Accounts	Bank	Today	Future
Bank			
Co-op	£ 944.96	£ 67.53	£ 63.53
Smile	£ 153.98	£ 1,976.62	£ 1,707.77
Total	[illegible]	**£ 2,044.15**	**£ 1,771.30**
Asset			
Cas...	[illegible]	£ 4,750.00	£ 4,750.00
Tax ...	£ 3,750.00	£ 6,000.00	£ 6,000.00
Total	**£ 8,500.00**	**£ 10,750.00**	**£ 10,750.00**
Credi...			
Co-...	£ -258.23	£ -231.38	£ -238.57

Top spending £ -9,533.53

Category	Amount	Share
Job Expense:Non-Reimbursed	£ -3,555.99	37.30%
Food	£ -1,695.00	17.78%
Bills:Mortgage Payment	£ -1,648.17	17.29%
Pension	£ -480.00	5.03%
Utilities	£ -274.00	2.87%
Travel/Vacation:Lodging	£ -216.98	2.28%
Automobile:Maintenance	£ -209.38	2.20%
Charitable Donations	£ -207.04	2.17%
Pet Care:Veterinarian	£ -155.13	1.63%
...		

Late	Next date	Payee	Memo	Expense	Income	Account
	08/01/19	Anglian ...	Water bill	£ -47.00		Smile
	08/01/19	Paragon	Web hos...	£ -3.59		Co-op
	10/01/19	Eastern ...	Water tr...	£ -9.53		Smile
	13/01/19	Aviva	Endowm...	£ -55.25		Smile
	15/01/19	Co-op B...	Everyda...		£ 4.20	Co-op
	15/01/19	Liberal ...	Liberal ...	£ -2.50		Co-op
	16/01/19	UNICEF	UN[illegible]	£ -5.00		Co-op
	22/01/19	Colchest...	Foo[illegible]...	£ -20.00		Co-op
	22/01/19	Guardia...	Guardia...	£ -5.99		Co-op
	22/01/19	Havens ...	Havens ...	£ -4.34		Smile
	24/01/19	Co-op In...	Car insur...	£ -30.43		Smile

maximum post date 08/01/19

Co-op VISA Bank: £ -258.23 Today: £ -231.38 Future: £ -238.57

Range: Entire range Type: Any Type Status: Any Status 45 transactions

Date	Info	Payee	Category	Tags	Status	Expense	Income
15/10/18		Co-op					£ 150.00
15/10/18		Premier Inn	Travel/Vacation:Lod...			£ -144.98	
16/10/18		Screwfix Direct	Household			£ -46.00	

1. QUICK ACTION BUTTONS
The toolbar offers a quick and easy way to access HomeBank's most popular functions.

2. ACCOUNTS LIST
All your accounts are listed here, grouped by category. Double-click one to open its own account window.

3. REPORTS
HomeBank provides several reporting tools that give you visual insights into how your finances are performing.

4. TRACK SPENDING
The pie chart shown on HomeBank's main screen gives you a convenient look at how your money is being spent.

5. SCHEDULED PAYMENTS
See which recurring transactions—incomings and outgoings—are due in the next few days.

6. ACCOUNT WINDOW
Manage each account in a separate window; you can add new transactions as well as view existing ones.

you enter a negative figure (such as -5.00) for a payment, so click the "+/-" button to change it to a negative if necessary.

» The "How Data is Broken Down" boxout (see left) explains how some of the other fields here work: "Payment" is the type of payment, deposit, or transfer between accounts you're making, while the "Info" field is usually used to record a check number or other related numbers. The "Payee" field refers to the business or person you're paying—HomeBank stores the names, making repeat payments simpler and more consistent.

» The "Category" field is essential for tracking your spending in more detail—many pre-filled categories are supplied, some rather quaint ("Tapes and CDs"?), but you can edit these via the "Manage → Categories" option on the main window. Categories are either expenses or income (they can't be both), so if you attempt to enter the wrong figure—say a positive number in an expense category—you'll see an amber alert.

» Selecting categories from the drop-down menu is time-consuming. Instead, start typing the category or subcategory you wish to use—HomeBank displays a list of matching categories, enabling you to quickly click the one you wish to use. The format is category:subcategory, and the quickest way to create your own is to simply type it here—for example, "Hobbies/Leisure:CDs, DVDs, and Blu-rays." It's then added as a subcategory, and made available to all other transactions.

4

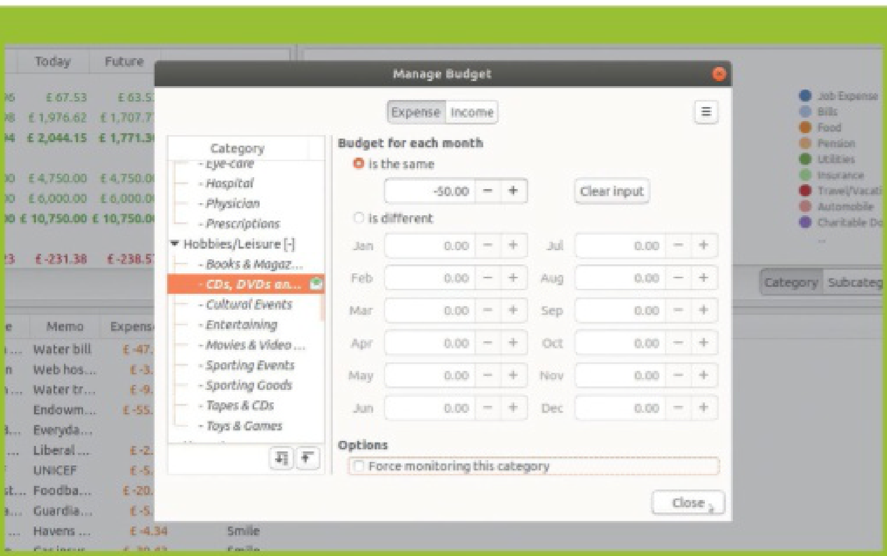
STATUS SYMBOLS

You'll notice four "Status" buttons appear, these enable you to verify whether a payment's cleared (appears on your account) or reconciled (appears in your statement). The "Remind" option exists for future payments you need to make manually.

» The final two fields–"Memo" and "Tags"—are optional. Use "Memo" to record information about the transaction, such as its purpose (paying a specific bill, perhaps, or bought a particular Blu-ray?), while "Tags" offers another way of tracking spending. Use it to add another extra layer of detail to your transactions—you could, for example, tag a specific type of spending within a category for future reference.

» Once you've input a transaction, click "Add" to add it, or "Add & keep" to add the transaction, but create a new transaction pre-populated with the previous one's contents. You can then move on to the next transaction, and so on. Click "Close" when you're done.

» Entering every transaction is time-consuming, even allowing for HomeBank's built-in auto-fill shortcuts for payees and categories. Thankfully, there are four ways to speed this up. First, simply duplicate an existing transaction—select the one you want to use



Budget for each month
● Is the same -50.00
○ Is different
Jan 0.00 Jul 0.00
Feb 0.00 Aug 0.00
Mar 0.00 Sep 0.00
Apr 0.00 Oct 0.00
May 0.00 Nov 0.00
Jun 0.00 Dec 0.00
Options
☐ Force monitoring this category

SET BUDGETS

One way to curb your spending is by setting monthly limits on what you spend on specific categories. By default, all accounts are included in budgets. If you want to exclude individual accounts for any reason, open "Manage → Accounts" from the main screen, select your account, and check "Exclude from the budget" on the "Options" tab.

Next, set your budget or budgets via "Manage → Budget." Verify that "Expense" is selected, so only expense-related categories and subcategories are visible. Select the one you want to track. From here, you can set a monthly budget or set budgets for different months of the year. When entering your budget, remember to add the minus (-) figure before it to indicate an expense and not income you're tracking.

At the bottom, you'll see a "Force monitoring this category" box—when a specific budget has no spending against it, it's not displayed in the budget report. If you want it to appear regardless, check this box. Repeat for any other subcategories, then switch to the "Income" tab if you want to set yourself saving targets, this time setting positive targets against income-related categories and subcategories. Once done, click "Close."

Going forward, you can monitor your budgets via the "Budget report" screen, accessible from the main screen's "Reports" menu.

as a basis for your new transaction, then choose "Transaction → Inherit." Make any changes—such as the date and amount—before clicking "Add."

» The second method involves scheduled transactions—recurring income and expenditure that occurs on a regular basis, from your monthly mortgage payments to quarterly direct debits. The third option is to set up transaction templates, which pre-fill as little or as much of a transaction as you wish. This is perfect for irregularly recurring one-off transactions, such as feeding your second-hand DVD habit.

» Set up both from "Manage → Scheduled/Template" in the main HomeBank window. Choose the type of transaction—scheduled or template—at the top, then click "Add" to create your first transaction of this type. The name of the template—"(template 1)" by default—is set in the "Memo" field, while the rest of the form is identical to a regular transaction. If you choose "Scheduled" over "Template," you also gain access to a Scheduled insertion section, where you can choose the next payment date, set future automatic payments, and even adjust for weekends. Check "Activate" to make the schedule active, and make use of the "Stop after" section if you're setting up a finite number of payments (for example, for a six-month loan).

» From here, scheduled transactions are entered automatically when their due date falls. You can see a list of upcoming scheduled transactions in the main window, enabling you to anticipate their arrival. Select a transaction and click "Post" to enter it, or "Post & Edit" if you wish to change details just for the next payment only (double-click the scheduled entry to make permanent changes via "Manage → Scheduled/Template"). Finally, click "Skip" to ignore the next payment. For a quicker way to process them all at the beginning of the month, to see how much will be left over, choose "Transactions → Set Scheduler," and you can configure HomeBank to quickly enter upcoming scheduled transactions. You can elect to enter all transactions up to a certain day of the month, or input transactions for a set number of days in advance. Once done, choose "Transactions → Post Scheduled" to post all outstanding transactions.

» Templates can be used when you come to add a new transaction—click "Use a template" to select them from a list, make any adjustments, then save.

5 AUTOMATIC ASSIGNMENTS

The final option is "Automatic assignment," which enables you to set the payee and/or category fields automatically, based on a text string in the "Payee" or "Memo" fields. For example, if you enter "music DVD" in the "Memo" field, it could be used to assign the appropriate subcategory automatically.

» It's primarily designed to help correct issues after importing data from another program, but it can also be used to tidy up previously entered data, or simply speed up transaction entries by enabling you to fill in just part of the transaction before running the assignment to automatically fill in the rest.

» To set this up, select "Manage → Assignments," then click "Add." Select the condition—the rules that determine if the assignment is automatically triggered. Select where to search ("Memo" or "Payee"), enter your text string, then select if you wish to match the case. There's also an option for using regular expressions for those proficient in using regex to produce more complex conditions (see https://regexr.com).

» You can then choose what payee, category, and/or payment type should be assigned to the transaction when the assignment is run. "Disabled" is self-explanatory, while "Overwrite" should be used with care. In most cases, choose "If empty," which ensures the field is left alone if you've already set it.

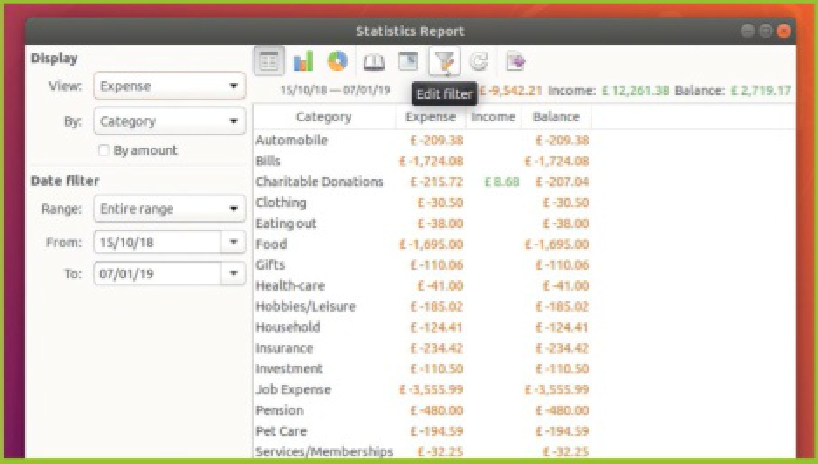
» You can set up as many assignments as you wish, but you can't run individual assignments independently of the rest—it's very much an all-or-nothing approach. Once set up, automatic assignments are run on an account-by-account basis. Open the account window, and choose "Tools → Auto.assignments." You're told how many transactions have been updated as a result of your assignments—job done.

6 ANALYZE YOUR SPENDING

The simple act of recording your transactions should help you start to take back control of your spending. Just knowing how much money you have in your account after the next cycle of bills have been paid is a great way to curb spending. But HomeBank enables you to dig deeper. As you start to build up your transactions, you get an overview of your so-called "top spending" using the pie chart on the main screen.

» By default, this summary is set up to display your spending by category over the entire period that you

FILTER FINANCES THROUGH HOMEBANK



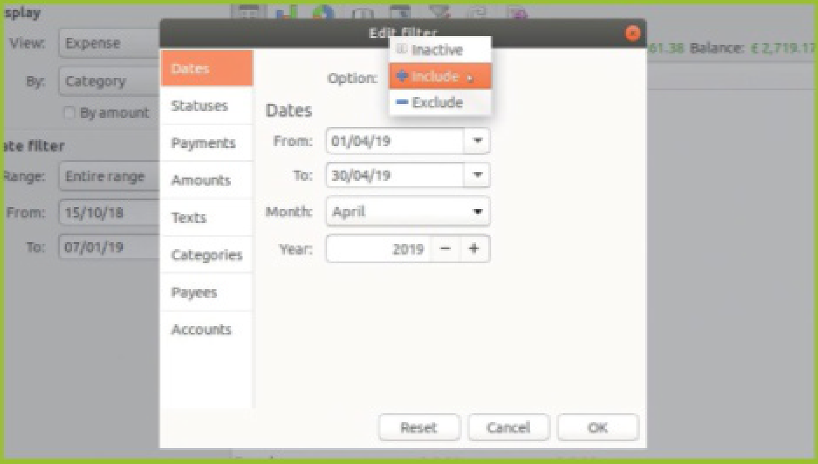
View: Expense
By: Category
Range: Entire range
From: 15/10/18
To: 07/01/19

15/10/18 — 07/01/19 £ -9,542.21 Income: £ 12,261.38 Balance: £ 2,719.17

Category	Expense	Income	Balance
Automobile	£ -209.38		£ -209.38
Bills	£ -1,724.08		£ -1,724.08
Charitable Donations	£ -215.72	£ 8.68	£ -207.04
Clothing	£ -30.50		£ -30.50
Eating out	£ -38.00		£ -38.00
Food	£ -1,695.00		£ -1,695.00
Gifts	£ -110.06		£ -110.06
Health-care	£ -41.00		£ -41.00
Hobbies/Leisure	£ -185.02		£ -185.02
Household	£ -124.41		£ -124.41
Insurance	£ -234.42		£ -234.42
Investment	£ -110.50		£ -110.50
Job Expense	£ -3,555.99		£ -3,555.99
Pension	£ -480.00		£ -480.00
Pet Care	£ -194.59		£ -194.59
Services/Memberships	£ -32.25		£ -32.25

1. CONTROL WHAT YOU SEE

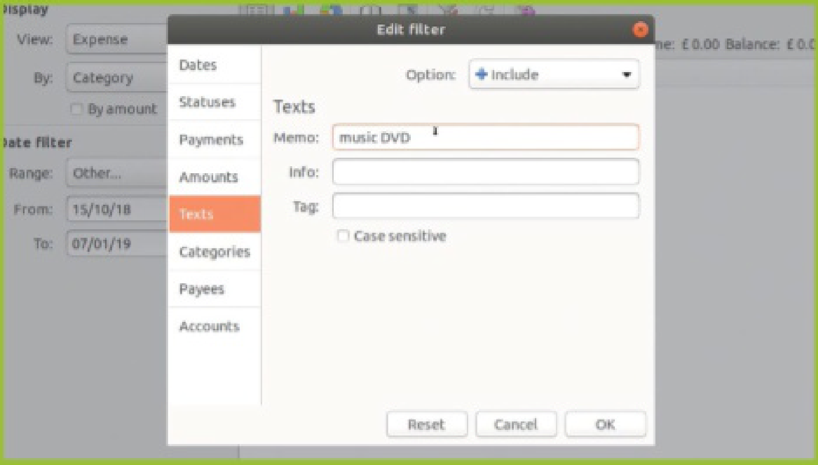
Filters enable you to restrict what HomeBank shows you. They're based on a tightly defined set of criteria, and can be applied both to the "Statistics" report and any account screen. Set up a filter in a report by clicking the "Edit Filter" button at the top of the report window. When viewing an account, you need to select "Tools → Filter."



Dates
From: 01/04/19
To: 30/04/19
Month: April
Year: 2019

2. SELECT FILTER TYPE AND OPTION

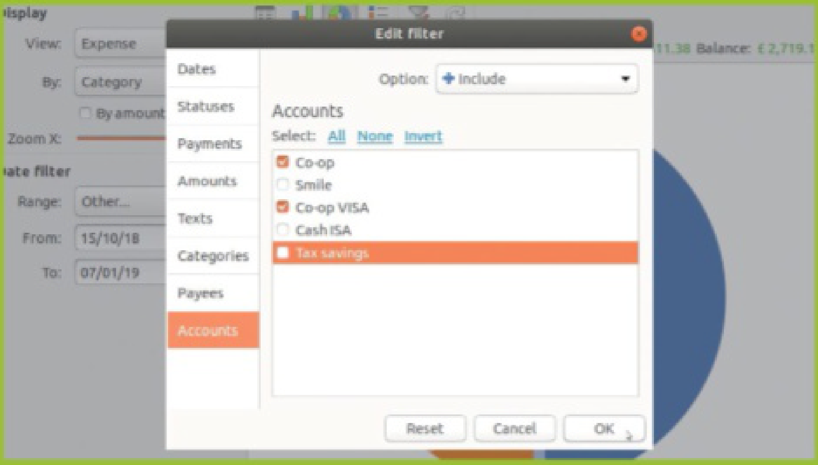
There are eight filter types available, including "Dates," "Payees," and "Accounts." You can select one or more types to construct your filter. Start by selecting a filter option: "Include" means only those transactions meeting the criteria (a date range, for instance) are included; "Exclude" means transactions falling outside the criteria are included instead.



Option: Include
Texts
Memo: music DVD
Info:
Tag:

3. SET YOUR FILTERS

Each filter has different criteria depending on its type—a range for dates, options for showing reconciled or cleared transactions under "Statuses," and so on. Use "Amounts" to filter payments by their size, while" Texts" enables you to filter by text string using the "Memo," "Info," and/or "Tag" fields. "Categories," "Payees," and "Accounts" filters work by selecting one or more from each.



Option: Include
Accounts
☑ Co-op
☐ Smile
☑ Co-op VISA
☐ Cash ISA
☐ Tax savings

4. REVIEW AND TWEAK

Once done, click "OK" to see the effects of your filters. If nothing shows up, reopen the filter dialog, and go through your filters again. Be sure to set unwanted filters to "Inactive," so they don't interfere. Note also that "Texts" filters work on the entire string—it's not an AND or OR-type filter that's performed. Click "Reset" to remove all filters if necessary to start again.

have been recording your financial transactions. For a more detailed view of specific subcategories—the cost of servicing your car, for instance—simply click "Subcategory." You can also focus in on specific time periods by clicking the "Entire range" drop-down menu—options here include the previous 30, 60, 90, or 365 days, plus the current or previous month, quarter, or year.

» This is a handy overview, but you can go further. You'll see a series of five icons above this view, offering you more ways to analyze your accounts: statistics, trend time (see how your spending is concentrated into specific periods), balance report, budget report (see the boxout on budgeting, on the left), and a special vehicle cost report.

» The statistics report is potentially the most useful—and configurable. This opens to show all your expenses divided up into categories, but you can use the drop-downs to track income, expenditure and income, and your account balance, plus filter by subcategory, payee, tag, month, or year. Check "By amount" to sort the list to show where most of your money is going. There's also a date filter that works in the same way as the main screen, with the added option of specifying an exact date range to track.

» Icons across the top of the window enable you to view this information in bar or pie chart form. There are also two toggles for displaying additional information: a details pane for displaying all transactions within the selected category or subcategory; and a rate that reveals how the spending breaks down as a percentage. You'll also see a filter button, which enables you to build up a specific view of your spending—the step-by-step guide (above) reveals how it works. Not only can you display these results on screen, but there's a button that makes it possible to export the information to the clipboard or a CSV file for accessing in a spreadsheet.

» You're now armed with the basics of what you need to take control of your spending. Follow our advice to input at least three months' worth of data from your account statements, and look to track as many accounts as you can to give you a more accurate picture of your net worth. ⏻

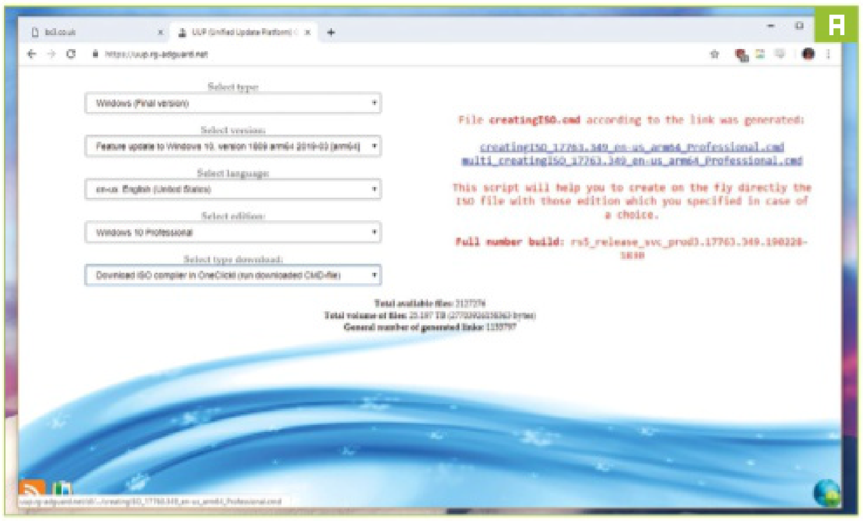
Run Full Windows 10 on Raspberry Pi

YOU'LL NEED THIS

RASPBERRY PI 3 B OR B+
Along with a 32GB microSD card.

THERE COULD COME A DAY WHEN WINDOWS 10 is on more ARM devices than it is on X86 devices. Perhaps that sounds a little mad, but Qualcomm (for one) is now pushing out mobile chipsets with more than enough grunt to manage it, and proper laptop manufacturers are jumping aboard the Windows 10 on ARM train—it means better battery life, enhanced mobile connectivity, instant return from standby, and many other quality-of-life improvements that may or may not outweigh the comparatively slashed computing power of running Windows on a RISC-based platform.

Fancy trying it yourself, but without any of those benefits? Don't expect the best results, as the Raspberry Pi is just about the most neutered platform capable of running Windows 10 on ARM, and an SD card is a terrible choice to boot from. Boot times could run to around 15 minutes, and your Pi is likely to get very hot. This ain't practical. But as an experiment as to what's possible, it's a fun diversion, and we can certainly offer some pointers as to how to make your Windows 10 experience a bit more tolerable on the tiny single-board computer. **–ALEX COX**



Select type:
Windows (Final version)

Select version:
Feature update to Windows 10, version 1809 arm64 2019-03 [arm64]

Select language:
en-us: English (United States)

Select edition:
Windows 10 Professional

Select type download:
Download ISO compiler in OneClick! (run downloaded CMD-file)

File **creatingISO.cmd** according to the link was generated:

creatingISO_17763.349_en-us_arm64_Professional.cmd
multi_creatingISO_17763.349_en-us_arm64_Professional.cmd

This script will help you to create on the fly directly the ISO file with those edition which you specified in case of a choice.

Full number build: rs5_release_svc_prod3.17763.349.190228-1630

1 GET WINDOWS

Even if you have a spare copy of Windows 10 laying around, you need to generate a special ARM-based image to run it on the Raspberry Pi. The code you're sitting on is unlikely to be compatible unless you're hoarding random ISOs for platforms you don't use—but if you do happen to have an up-to-date arm64 build of Windows 10, by all means skip this next couple of steps.

» Our first task is to head AdGuard's online tool at http://uup.rg-adguard.net [**Image A**], which sniffs out official Windows builds from Microsoft's servers, and gives you a useful interface to get hold of them. Using the drop-down boxes, select a final version (unless you want to go all bleeding edge with an Insider build), choose the latest arm64 edition (be sure you don't select amd64), the appropriate language, opt for Windows 10 Professional, and in the final box, select "Download ISO Compiler in OneClick!" Click the top link on the right-hand side, download it wherever you like, and run the CMD file. Windows SmartScreen will likely step in at this point; click '"More info," and opt to run it anyway.

2 CREATE THE IMAGE

A command line window pops up, detailing the process of downloading the required files [**Image B**] and squashing them into a deployable Windows image. This takes a while, and might look as though it's stalled, but when you've waited patiently as it integrates all the relevant Windows updates, you're left with an ISO file. Double-click this to mount it, head to the "/sources" folder within, and drag the file "installer.wim" out of the ISO to a folder on your main PC. This is the install file we'll use to put Windows 10 on to our spare SD card; you can now unmount the ISO.

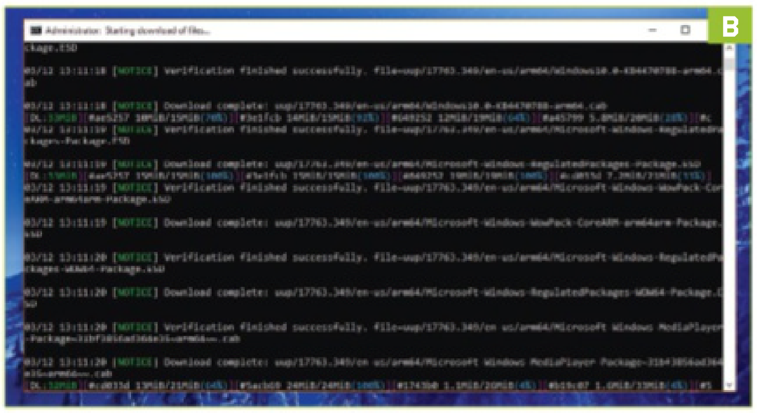
3 WRITE THE SD CARD

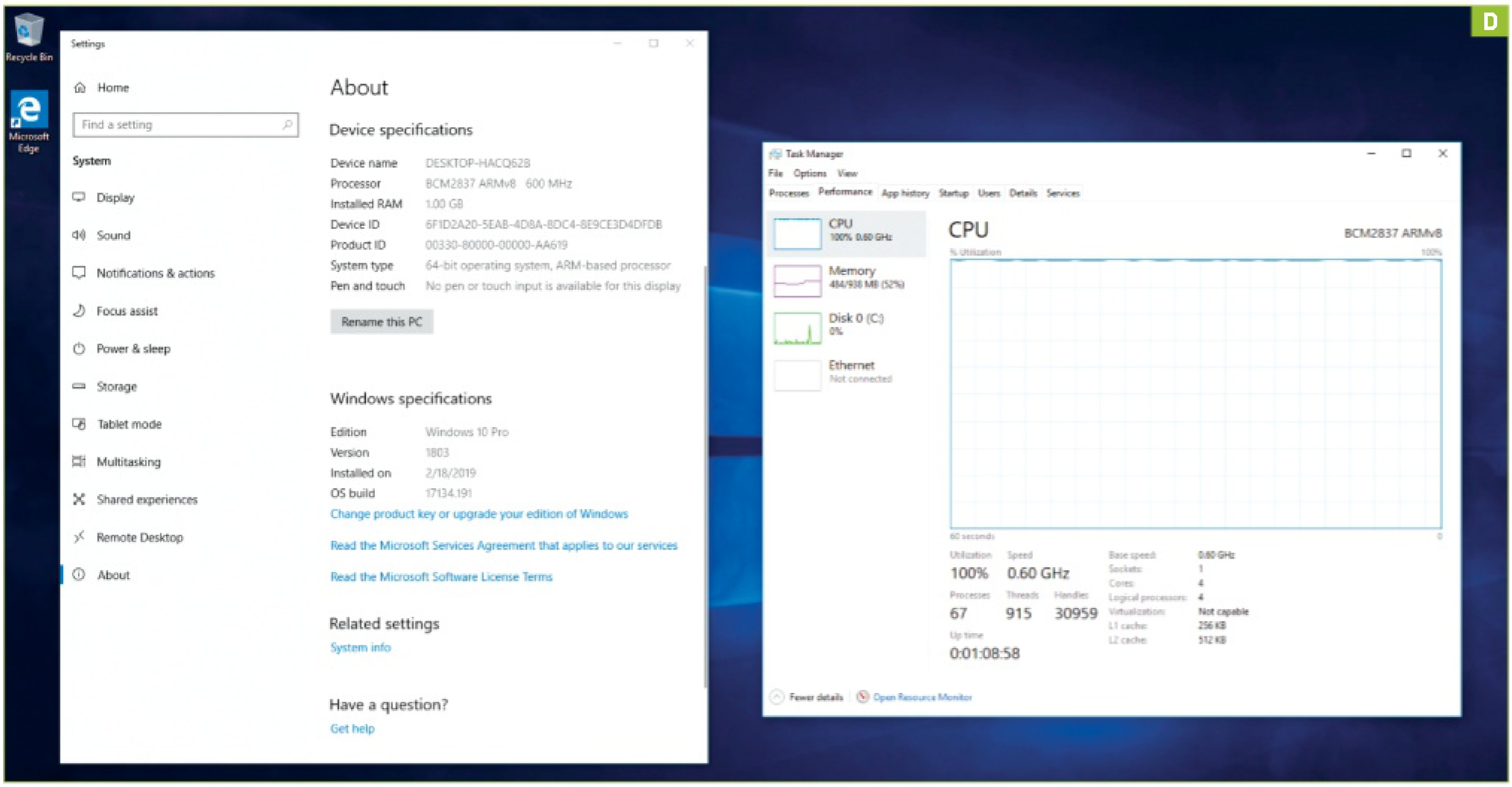
Go to http://pi64.win, click the link to find the deployment tool, scroll down to "Latest version," then download the ZIP file linked on the page that follows. Extract it to a folder, head on in, and (once you've inserted your microSD card into your reader) run the executable within the folder to see the pretty interface. Again, SmartScreen sniffed at us—ignore its warnings; you already know you're doing something a bit stupid.

» Everything here is quite straightforward. Under "Drive Selection," use the drop-down box to select your SD card reader; make sure you don't choose one of your main drives, lest it be wiped from existence. In the "Windows Image" box, point WOA Deployer at the "install.wim" file we pulled out earlier. It should show the build of Windows you're going to install—it's possible to create install.wim files containing multiple Windows builds, which you can select using the drop-down, but that's a tutorial for another day. When happy, hit "Deploy."

4 COMPLETE THE INSTALL

There are various things you need to agree to over the course of the deployment—it's not just a case of writing Windows 10 to an SD card. The WOA




D

About

Device specifications

Device name DESKTOP-HACQ628
Processor BCM2837 ARMv8 600 MHz
Installed RAM 1.00 GB
Device ID 6F1D2A20-5EAB-4D8A-8DC4-8E9CE3D4DFDB
Product ID 00330-80000-00000-AA619
System type 64-bit operating system, ARM-based processor
Pen and touch No pen or touch input is available for this display

Windows specifications

Edition Windows 10 Pro
Version 1803
Installed on 2/18/2019
OS build 17134.191
Change product key or upgrade your edition of Windows
Read the Microsoft Services Agreement that applies to our services
Read the Microsoft Software License Terms

Related settings
System info

Have a question?
Get help

CPU 100% 0.60 GHz
Memory 484/938 MB (52%)
Disk 0 (C:) 0%
Ethernet Not connected

CPU BCM2837 ARMv8
% Utilization 100%
60 seconds 0
Utilization 100%
Speed 0.60 GHz
Processes 67
Threads 915
Handles 30959
Up time 0:01:08:58
Base speed: 0.60 GHz
Sockets: 1
Cores: 4
Logical processors: 4
Virtualization: Not capable
L1 cache: 256 KB
L2 cache: 512 KB

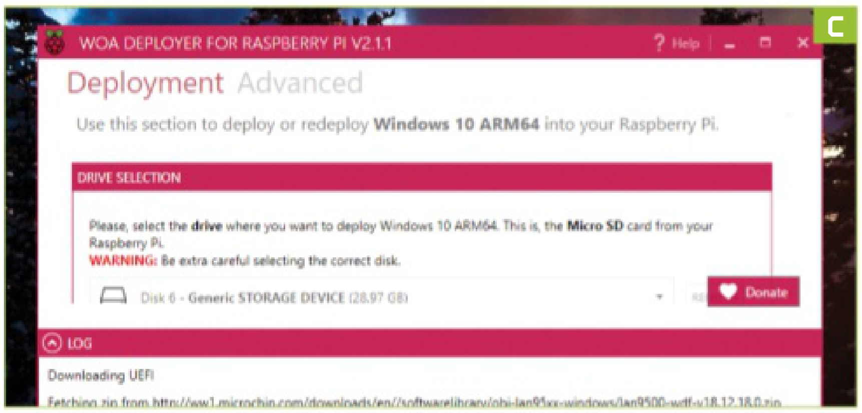
Deployer adds things like a virtual UEFI setup, USB drivers, and LAN drivers, so you need to click the odd "Accept'" button to confirm you've signed your life away. Let it tick for a while, and don't be fooled if it seems to stall [**Image C**], just be patient; even after the image is written, the deployment, which brings it up to date with the latest patches, takes its sweet time. Don't rush to whip out your card the second WOA Deployer says it's finished, either—it injects a few drivers after you've clicked "OK."

5 FIRST BOOT

If you thought waiting for deployment to complete was fun, wait until you take your SD card, put it in your Pi, and power it on. First you need to set your UEFI options; type "exit" at the initial prompt, head to "Boot Maintenance Manager" in the UEFI interface, and change the boot order so that "SD/MMC on Broadcom SDHOST" is listed first. Select "Commit changes and exit," hit Esc a couple of times, then select "Boot Manager" on the first screen, and hit Enter on "SD/MMC." Now wait, and watch that lovely Windows spinning circle for a while. If you see an error at this point, it's likely to be the fault of the SD card you've written to; first time around, we received a driver error when Win 10 was written to a Kingston 32GB Class 10 card, but booted just fine when we switched to a 64GB Sandisk card in gold livery.

6 MAKE IT FASTER

It's quite the sluggish boot experience, because of both the slow ARM processor and the generally terrible I/O performance of the SD card it's running on. Give it time, though, and you'll hit the standard Windows 10 initial setup—walk through it, wait some more, and you end up at the Windows desktop running in test mode [**Image D**], and you'll be ready to make a few essential tweaks. First off, disable Cortana—there's even less benefit to having the voice assistant here—and switch off Windows' cached searches, too. If you're feeling really gung-ho, a trip back to the UEFI menu on reboot enables you to boost the clock speed up from the default 600MHz to 1GHz, and leave your Pi even toastier than it is by default; you can, if you're happy for your hardware to fry itself, open the config file by putting your SD card back into your PC, and up the clock speed even further there. ⏻


C

Use this section to deploy or redeploy **Windows 10 ARM64** into your Raspberry Pi.

Please, select the **drive** where you want to deploy Windows 10 ARM64. This is, the **Micro SD** card from your Raspberry Pi.
WARNING: Be extra careful selecting the correct disk.

Disk 6 - Generic STORAGE DEVICE (28.97 GB)

```
Downloading UEFI
Fetching zip from http://ww1.microchip.com/downloads/en//softwarelibrary/obj-lan95xx-windows/lan9500-wdf-v18.12.18.0.zip
```

WINDOWS 10 VS. WINDOWS 10 IOT

Why go through all this bother when there's a perfectly good skew of Windows 10 available for the Raspberry Pi? That may be true, but Windows 10 IoT just isn't Windows 10. It's a severely trimmed-down version designed, as its name suggests, for Internet of Things devices. If you're looking to apply your Raspberry Pi to a single task, such as digital signage, robotics, or similar, Windows 10 IoT Core (think Windows CE, if you're old-school) is the OS for you, as long as there's a Universal App, designed to run on an ARM processor, that you're sure will do the job.

If not, and if full Windows 10 doesn't do what you want it to (spoiler: It probably won't), you may well be better off sticking to the Raspberry Pi's more familiar Linux-based operating systems, such as Raspbian. Linux may be less familiar than Microsoft's warm embrace, but it's far better documented. If there's something you need to do, some bit of hardware you want to interact with, someone's probably created a guide to doing it, and Linux is built for tinkering.

Make a Video with Shotcut

YOU'LL NEED THIS

SHOTCUT
Grab this open-source app from www.shotcut.com.

VIDEOS ARE A GREAT WAY TO SHARE special experiences and events, and making them doesn't have to be complicated or expensive. Shotcut is a completely free open-source video editor that's easy to use, and is packed with an impressive selection of filters and special effects that can help bring your home video projects to life.

If you've ever used Windows Movie Maker, Shotcut will feel immediately familiar, but even if you haven't, its design is intuitive enough that you'll be able to master it in moments.

To get your project started, all you need is a collection of media files (videos, audio, and photos), an Internet connection, and 30 minutes. Once you've finished, you'll have a video that looks and sounds as though it was made with professional software, and is ready to upload to Facebook or YouTube. –**CAT ELLIS**

1 DOWNLOAD AND INSTALL SHOTCUT

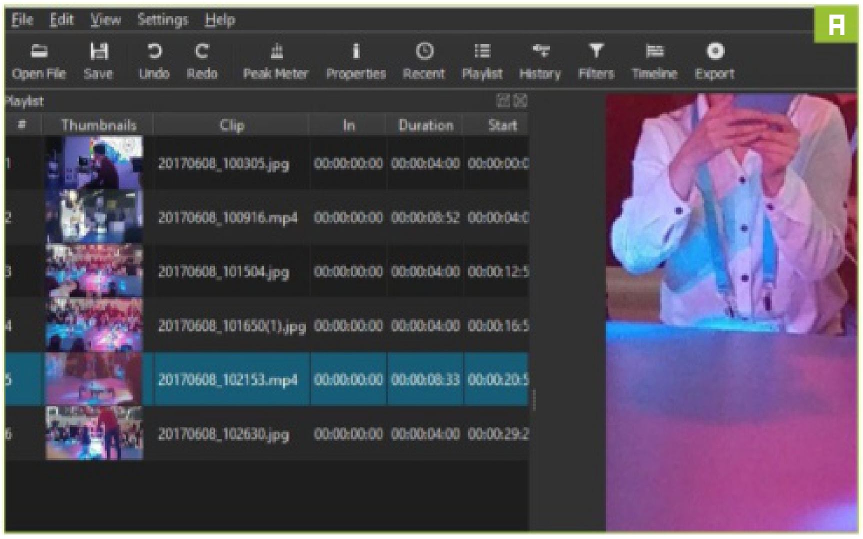
Go to www.shotcut.com, hit "Click to download," then choose either "64-bit Windows installer" or "32-bit Windows installer." If you're not sure which version of Windows you have, follow the instructions at https://bit.ly/2I6jNbI. When prompted, click "Save file," then click the downloaded file to run the installer. Read the terms, click "I agree," then "Next," and "Install."

2 CREATE A PLAYLIST

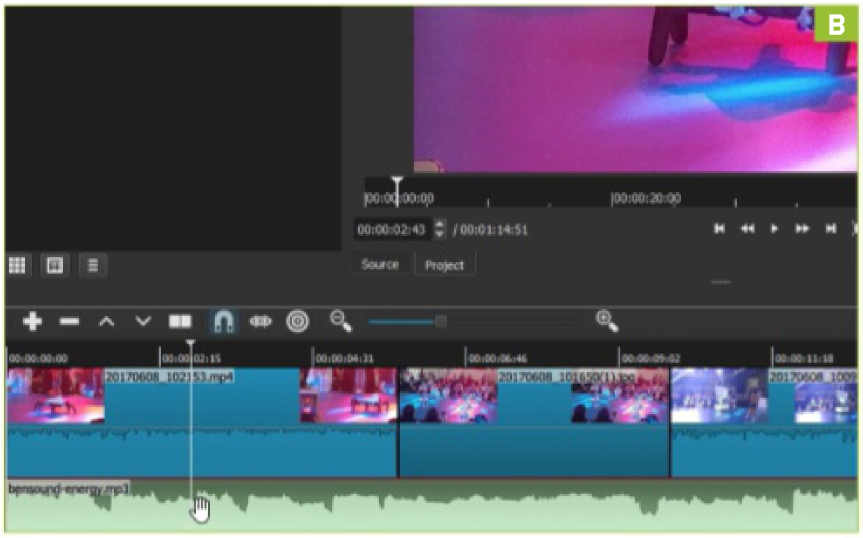
Launch Shotcut, click "File → Open," and select all the video and photo files you want to add to your project. They appear in a playlist on the left side of Shotcut [**Image A**]. You can add more files later or remove some using the "+" and "–" buttons under the playlist. To preview a video or image, double-click it, then use the "Pause" and "Play" controls under the playback window on the right.

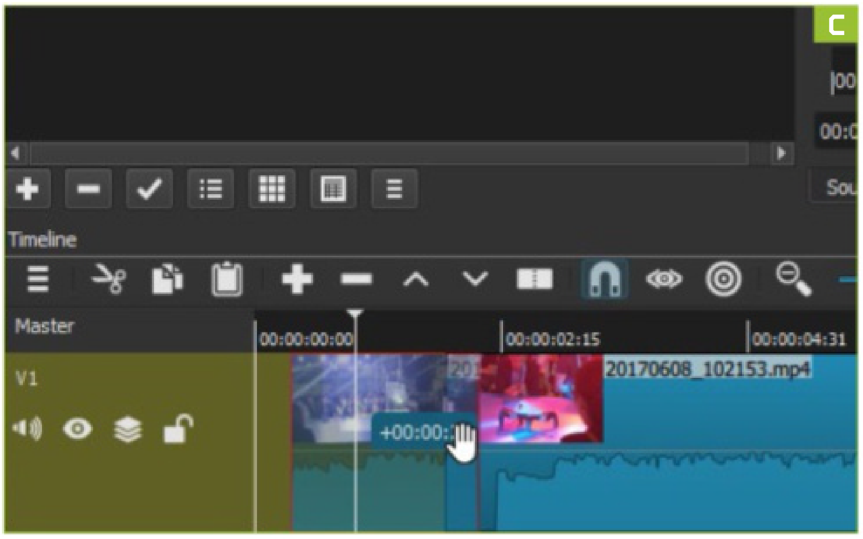
3 START BUILDING YOUR TIMELINE

Drag your first video clip or photo from the playlist into the gray area at the bottom of the Shotcut interface. This is your timeline. If you inserted a video clip, this is a good time to trim it, if necessary. Move your mouse pointer to the start or end of the video until it turns into a horizontal arrow, and drag it to shorten the clip [**Image B**]. You can change how long photos are displayed in the same way.


A
File
Edit
View
Settings
Help
Open File
Save
Undo
Redo
Peak Meter
Properties
Recent
Playlist
History
Filters
Timeline
Export
Playlist

#	Thumbnails	Clip	In	Duration	Start
1		20170608_100305.jpg	00:00:00:00	00:00:04:00	00:00:00:0
2		20170608_100916.mp4	00:00:00:00	00:00:08:52	00:00:04:0
3		20170608_101504.jpg	00:00:00:00	00:00:04:00	00:00:12:5
4		20170608_101650(1).jpg	00:00:00:00	00:00:04:00	00:00:16:5
5		20170608_102153.mp4	00:00:00:00	00:00:08:33	00:00:20:5
6		20170608_102630.jpg	00:00:00:00	00:00:04:00	00:00:29:2


B
00:00:00:00
00:00:20:00
00:00:02:43
/ 00:01:14:51
Source
Project
00:00:00:00
00:00:02:15
00:00:04:31
00:00:06:46
00:00:09:02
00:00:11:18
20170608_102153.mp4
20170608_101650(1).jpg
20170608_1009
bensound-energy.mp3


C
Timeline
Master
V1
00:00:00:00
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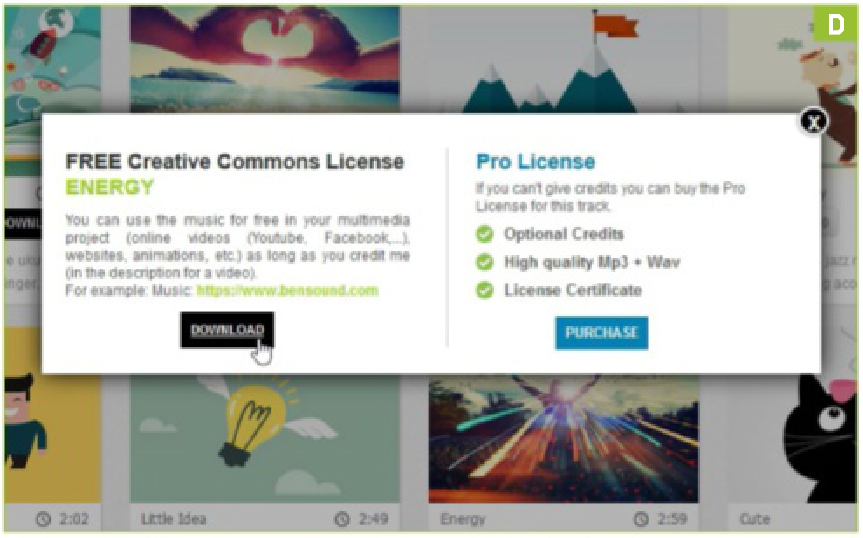
00:00:04:31
20170608_102153.mp4
+00:00:


D
2:02
Little Idea
2:49
Energy
2:59
Cute

FREE Creative Commons License
ENERGY
You can use the music for free in your multimedia project (online videos (Youtube, Facebook,...), websites, animations, etc.) as long as you credit me (in the description for a video).
For example: Music: https://www.bensound.com

DOWNLOAD

Pro License
If you can't give credits you can buy the Pro License for this track.
- ✓ Optional Credits
- ✓ High quality Mp3 + Wav
- ✓ License Certificate

PURCHASE

4

REARRANGE YOUR FILES

Drag another file into the timeline after the first. Shotcut inserts empty space between the two, represented by a yellow block. To remove this, right-click it, and select "Remove." To split a clip, click the timeline where you want to divide it, then tap S on your keyboard. You can rearrange sections using drag and drop, and use Ctrl-C and Ctrl-V to copy and paste [Image C].

5

FIND SUITABLE MUSIC

Once you've added your clips and photos, use the "–" button to remove them from the playlist. Now add some music. Take care not to use songs protected by copyright. To avoid legal issues, download tracks from www.bensound.com that have been released under a Creative Commons license [Image D]. These are free to use, provided you link back to the site in the description when sharing.

6

ADD A NEW AUDIO TRACK

Tap Ctrl-U to create a new audio track, click "Open file," select a music file, and click "Open." The music begins playing. Click the "Pause" button under the preview window, then click the "+" icon under the playlist to add it. Click the three-line "hamburger" icon under the playlist, and select "Add all to timeline" [Image E]. Drag the music on to the new audio track. If it's too long, you can trim it.

7

ADD TITLES

Click the first video clip or image in your timeline, then click "Filters" (the funnel icon at the top), and click the "+" icon. Click the monitor icon underneath the list to just see visual effects, and scroll down to "Text." Select this, type the words you want to appear into the box that currently says "#timecode#," then use the font and positioning options below to change how the title looks [Image F].

8

APPLY OTHER EFFECTS

Let's experiment with some other effects. Click a different video clip or photo, then click the "+" icon again, and choose a different visual effect. The "Fade in" and "Fade out" options [Image G] are particularly effective, and are a great way to transition smoothly between the different parts of your video, and the "Old film" filters are a fun way to bring photos to life with realistic grain and jitters.

9

EXPORT YOUR VIDEO

Before you export your finished video, save the project file so you can edit it again later. Tap Ctrl-S to save it as an MLT file, which you can reopen with Shotcut whenever you want. Now click "File → Export video." The settings look complicated, but the default options are ideal for uploading to YouTube or Facebook. Make sure "Format" is set to MP4—the rest is fine.

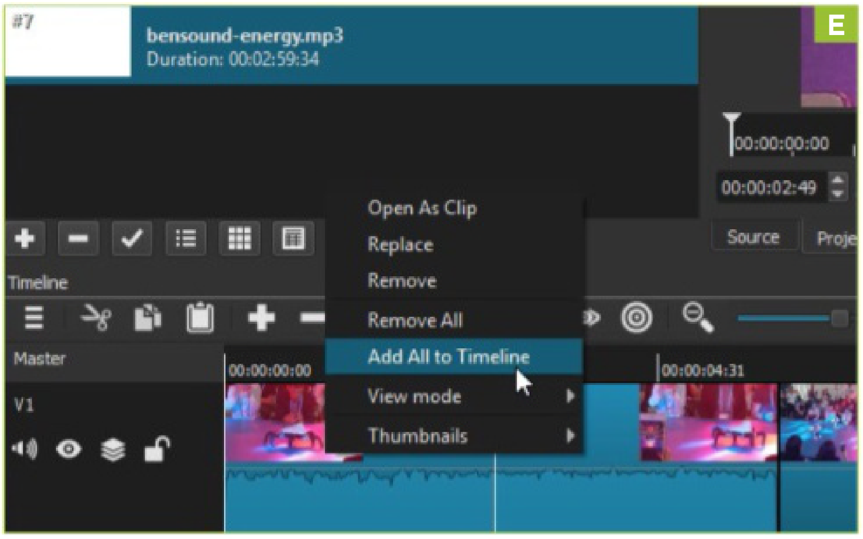
10

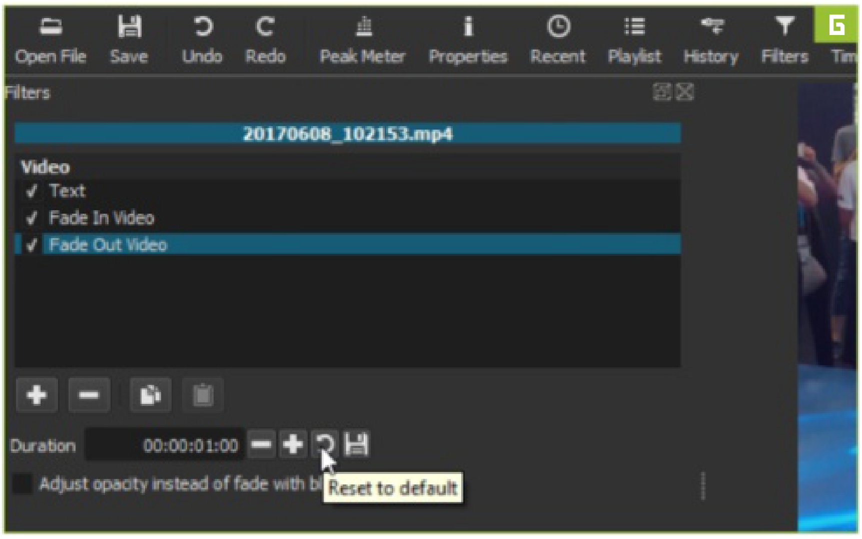
SHARE WITH THE WORLD

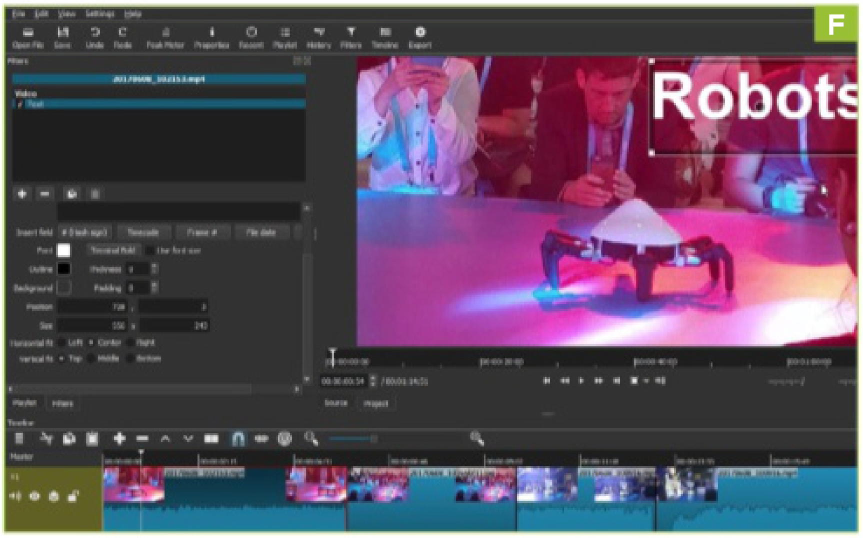
Click "Export file," give your video a name (including the extension ".mp4"), and click "Save." It might take a while for the file to render, but you can keep an eye on its progress in a panel on the right side of Shotcut's interface. Once it's done, you can watch it in your usual media player, or upload it to Facebook or YouTube for friends and family to enjoy [Image H]. ⏻

IMAGE IS IMPORTANT

To make a great-looking video, you need good files to work with—try to avoid camera shake where possible.


E
#7
bensound-energy.mp3
Duration: 00:02:59:34
00:00:00:00
00:00:02:49
Source
Proje
Timeline
Open As Clip
Replace
Remove
Remove All
Add All to Timeline
View mode
Thumbnails
Master
V1
00:00:00:00
00:00:04:31


G
Open File
Save
Undo
Redo
Peak Meter
Properties
Recent
Playlist
History
Filters
Tim
Filters
20170608_102153.mp4
Video
✓ Text
✓ Fade In Video
✓ Fade Out Video
Duration
00:00:01:00
Adjust opacity instead of fade with bl
Reset to default



Make Textured Paint Effects in Luminar 3

YOU'LL NEED THIS

LUMINAR 3
Buy the full version or download a time-limited trial from http://skylum.com.

ONCE, IF YOU WANTED TO MAKE AN IMAGE, you would have needed things such as canvas, plaster, or a cave wall, plus some sort of pigment, maybe a brush. And talent. Today, we have no need for any of those—we have PCs.

OK, maybe you still need talent. Brushes and canvas aren't needed, though. And for this tutorial, neither is a Creative Cloud subscription. We're using Luminar 3 from Skylum, a non-destructive image editing and raw conversion app that's often compared to Adobe Lightroom, but actually occupies a middle ground between that app and Photoshop. It has full support for layers, enabling you to build up a complex effect in which many different edits interact with one another. It's easier to use, however, thanks to its copious number of Looks and Filters, which are one-shot presets that can radically alter the image to which you apply them.

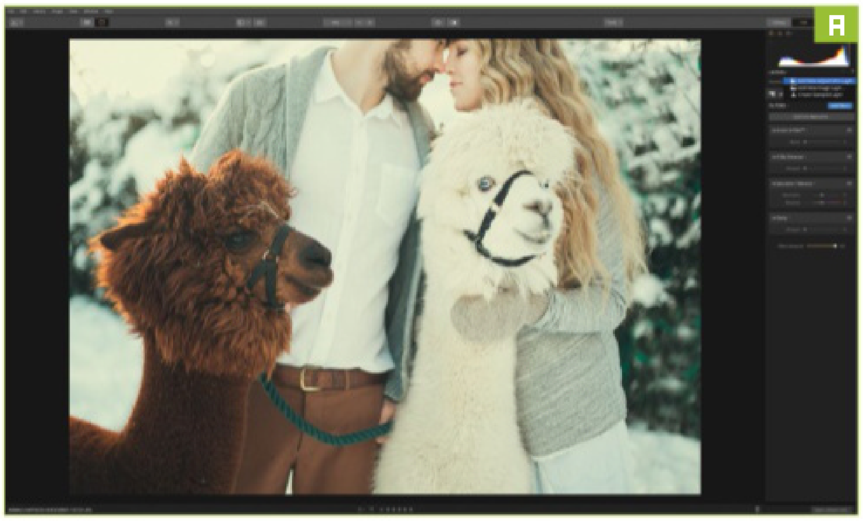
While Luminar might never replace Photoshop on our PCs or in our hearts, there's no denying it's a powerful app, and probably all many enthusiasts will need. It's a snappy performer, too, making use of multiple CPU cores, and taking advantage of GPU acceleration where it's available. Here, we're going to add textures to an image, before using masks and Filters to produce a canvas-like composition. If you don't want to shell out for the full package, a 15-day trial of Luminar 3 can be obtained from http://skylum.com. – **IAN EVENDEN**

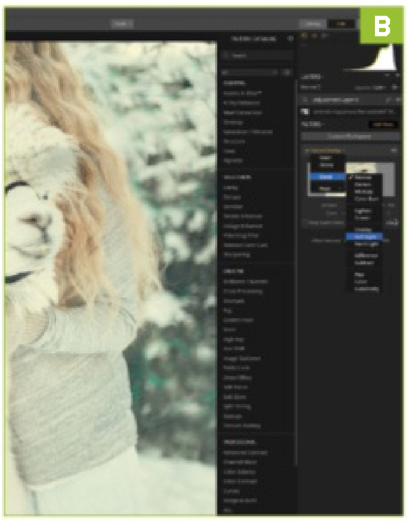
1 OPEN A PHOTO IN LUMINAR

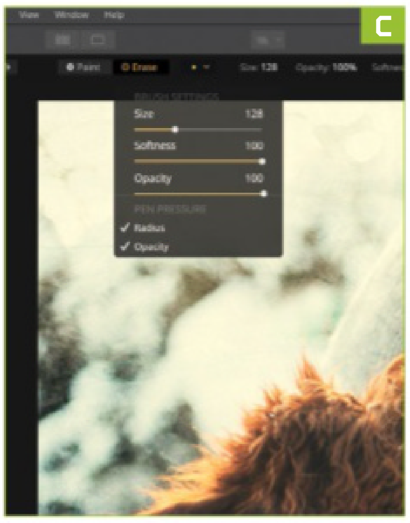
Our photo is a love story with added llamas. Or maybe they're alpacas—this isn't *Maximum Camelid* magazine, you know. Whatever you choose, it needs to be something that you could imagine hanging on a wall in a homewares store, quite large, perhaps printed on canvas that will add its own textured effect to the final result. You also need to find a texture image that you can merge with your main photo—there are plenty of free ones on the Internet. Luminar has a couple of ways of getting images into it—you can open an entire folder, and see it as a grid of images, from which you choose the ones you want to edit, or you can open a single image directly, which is what we've done here with the main image, using "Open Images for Quick Edit" from the "File" menu.

2 EDIT MODE AND LAYERS

Opening the image puts Luminar in Library mode. To actually do anything, you need to be in Edit mode, so change this using the buttons at the top-right of the interface. Add a new Adjustment Layer by clicking the "+" icon at the top-right of the Layers palette on the right, and choose "Adjustment Layer" from the drop-down [**Image A**]. With the new layer selected, hit the blue "Add Filters" button below it—a sidebar appears, with all Luminar's filters on it. As Luminar is a non-destructive editing app, you can apply whatever filters you want, then simply turn them off again, without affecting your original image. Feel free to experiment; you're not going to do any harm to your photo. The filter we're going to use is the Texture Overlay, which is in the "Creative" section—scroll to it, or use the search box.



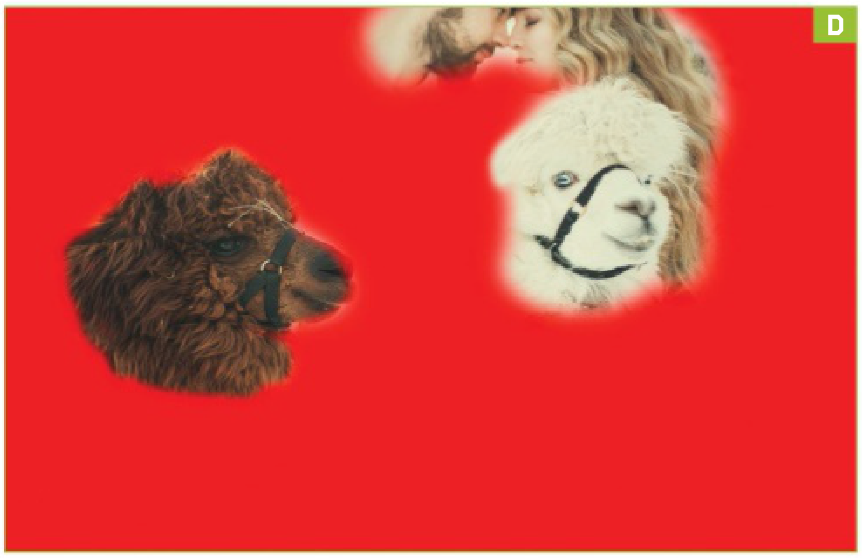




Size 128
Softness 100
Opacity 100

3 TEXTURE OVERLAY

The texture file we've chosen is a deeply unsubtle brush stroke image. Click the "Load Texture" box, navigate to where your texture image is, and open it as normal. It appears over the top of your main image, 50% blended with it, but still very visible. Change the "Amount" slider to 100%—this may seem counter-intuitive, as it completely hides the background image, but we're going to bring it back. Click the "Texture Overlay" filter name (in yellow), and a drop-down appears. Choose "Blend," and a list of options familiar to anyone who's used Photoshop appears [**Image B**]. Scroll through until you find one that's pleasing—we've chosen "Soft Light." If you want, you can go on to add more textures using the same technique, all on the same Adjustment Layer.



4 MASK THE TEXTURE

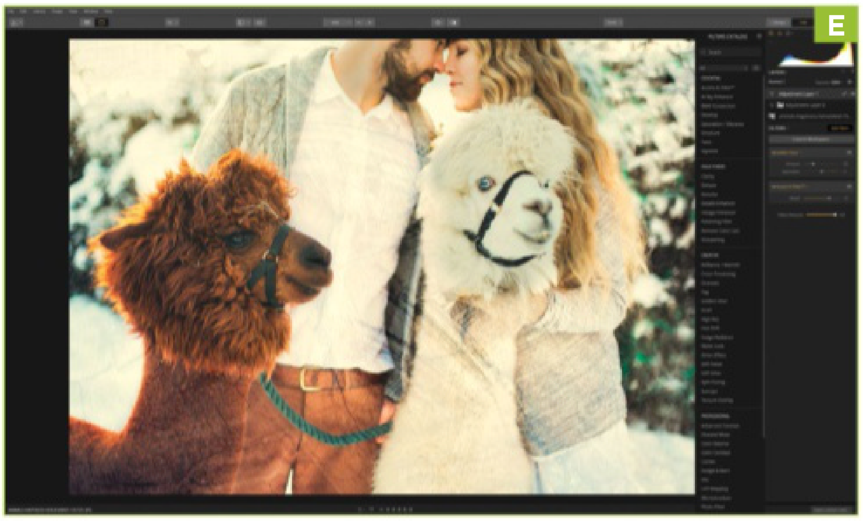
The textures we've chosen look great on the background, but are perhaps too much on the faces of the happy couple and their high-altitude-adapted friends. The Adjustment Layer we created has a brush icon on it—click this, and choose "Brush" from the drop-down, then "Erase" from the options at the top-left of the interface, next to "Paint" [**Image C**]. There's a "Brush Settings" drop-down one space to the right, so choose a brush size that suits, and erase the parts of the texture that don't work for you.

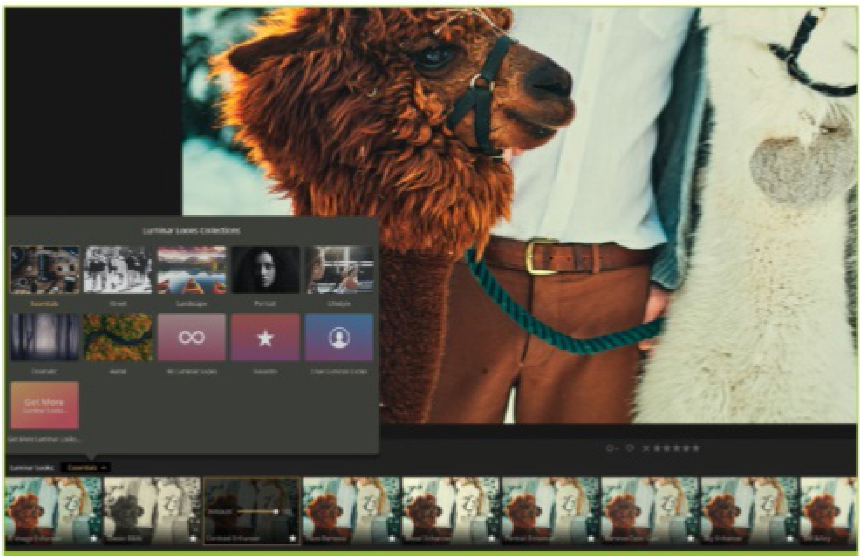
5 EDIT THE MASK DIRECTLY

If you want to see the areas you've masked, and edit them in this high-visibility mode, you can click the eye icon next to the word "Mask" at the top-right. This fills your composition with a sea of red, with only the areas you've masked off showing through [**Image D**]. You can use the "Paint" and "Erase" buttons to add and remove the red, maybe painting over some little areas you've missed, so when you click the eye again to go back to viewing the entire composition, your mask doesn't have any rough edges. Click the blue "Done" button at the top-left to apply the mask. By masking the layer, we've masked both of the texture filters we applied to it. If we'd wanted to, we could have masked the filters individually, removing different parts of each.

6 FURTHER FILTERS

Luminar's filters don't all work like Texture Overlay. More often, they work as one-shot changes to your image, and don't involve importing a separate file. Create a new Adjustment Layer on top of your textures. Our image is a little cold, so to counteract this, we're going to apply the Golden Hour filter. Unlike Texture Overlay, these filters are applied at 0%, which can catch you out if you're looking for an immediate change in your image—you need to drag the "Amount" slider up first. We've only gone to 25%, as it's quite a strong effect [**Image E**]. If your image doesn't need warming, consider filters such as Dramatic or Accent AI to bring out colors and detail—bear in mind that images printed out on big canvases are meant to be looked at from a distance, so subtle detail may get lost. Because your new layer is on top of the textures, the effects of your filters will be applied to them as well as the base image.



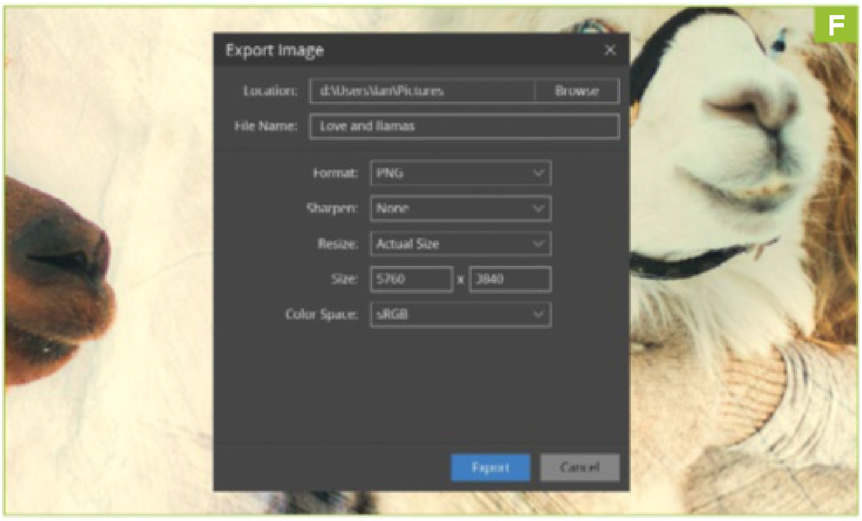


GET THE LOOK

Luminar has a second selection of filters called "Looks," accessible from a filmstrip at the bottom of the interface (there's a button at the top to toggle it on and off). You can click any of these to try them out, because clicking a new one replaces the previous one. However, you can build up a striking look by using several Looks on separate Adjustment Layers. There are many, many Looks available across seven categories, and you can find more on the Luminar website. Looks are one-shot presets for the Edit module, and as such can be altered once applied by using the sliders that appear on the right-hand side.

7 EXPORT

Because Luminar is a non-destructive image editor, your files are never changed—the edits you've made are held in a database file. To save your work, you need to create a new file using the "Export" command on the "File" menu, or the "Export" button at the far top-right. Either option brings up the same window, from where you can choose the format, size, and color space used for your file [**Image F**]. Hit "Export," and you have a new file ready to post online or share.



Location: d:\Users\Ian\Pictures
File Name: Love and llamas
Format: PNG
Sharpen: None
Resize: Actual Size
Size: 5760 x 3840
Color Space: sRGB

BUILD IT

CHRISTIAN GUYTON, STAFF WRITER

A Fresh New Start

The new face in the *Maximum PC* office sets about building his own computer

LENGTH OF TIME: **1–2 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

SETTLING INTO MY DESK at the *Maximum PC* office, my first task was, of course, to build a new PC. An exciting prospect for me, a former broke freelance journo—with an actual budget to play with, I was able to focus on what I really wanted, rather than merely what I could afford. In spite of this, I've opted for a relatively sensible build, ending up with a final price just shy of $1,500.

The name of the game here was silence. Using a Be Quiet! Silent Base 601 case (available with black, silver, or orange trim—used here) and a Zotac GeForce RTX 2060 graphics card as my starting point, the goal was to create an effective gaming machine that produced minimum noise. We reviewed the 601 back in December last year, awarding it nine out of ten for its clean design, effective sound dampening, and budget price point. While the front I/O is a little basic, the case is large enough to be lenient on a novice PC-builder, and has plenty of flexibility for future expansion and adjustment.

Case aside, this build revolves around the graphics card like a pre-Copernicus universe revolving around Earth. The 2060 isn't cheap, but it is powerful, running 1440p games at 60fps with ease, and keeping potential for future ray-tracing games, earning itself another 9/10 review in last month's issue. By far the most expensive piece of gear in this build, the rest of my choices were merely in service to the card. The end result, as I had hoped, is a whisper-quiet and efficient machine that doesn't break the metaphorical bank.

KEEPING IT SIMPLE

MY CHOICE OF PROCESSOR could be charitably described as conservative. The Intel Core i5-8400 is an 8th Gen Coffee Lake chip released in 2017, which shouldn't cost you more than $200 online. This is actually the exact CPU used as our base zero-point in benchmarks, although it's a tad sluggish in the wake of the Spectre and Meltdown fixes. It's not the flashiest choice, but it'll support the Zotac RTX 2060 GPU just fine. To keep it cooled, we chose Arctic's Freezer 33, a cheap but effective cooler unit.

For the motherboard, we opted for a Z370 Aorus Ultra Gaming 2.0 from Gigabyte. It's worth noting that the 2.0 is basically indistinguishable from the original Z370 Ultra, with the minor addition of a thermal shield for an M.2 drive, so whichever you can get your hands on will work great here. The Z370 also has some nice RGB effects, though those will be all but invisible inside the solid body of the Silent Base 601. The 601 does also come in a windowed variant, should you wish to show off your build's internals, but this leads to a trade-off in sound reduction.

Windows 10 is an obvious necessity, throwing an extra 100 dollars on top of the price. Everything else decided, the last big decisions were all memory-related. Two 8GB sticks of Ballistix Sport RAM from Crucial were the ideal choice, their smaller profile compared to bulkier offerings from Corsair meaning that they fit neatly into the motherboard. For storage, the main drive is an Intel 760p, providing 512GB of storage at a reasonable price. It's perhaps not the fastest option available, but it's certainly good value. In reserve, a Samsung 860 QVO gives a terabyte of storage to stuff files into.

INGREDIENTS

PART		STREET PRICE
Case	Be Quiet! Silent Base 601	$117
Motherboard	Gigabyte Z370 Aorus Ultra Gaming 2.0	$200
CPU	Intel Core i5-8400	$200
CPU Cooler	Arctic Freezer 33	$29
GPU	Zotac Gaming GeForce RTX 2060 AMP	$368
Memory	16GB (2x 8GB) Crucial Ballistix Sport LT DDR4-2400	$98
PSU	Corsair Builder 500W	$58
OS Storage	Intel 760p Series 512GB M.2-2280 SSD	$103
Data Storage	Samsung 860 QVO 1TB 2.5-inch SSD	$128
OS	Window 10 64-bit OEM	$100
Total		$1,401

1

FAN BASE

AS WITH ANY GOOD build process, the best place to start is stripping down the case. The 601 is a beautiful piece of straightforward design, both sound-proofed side panels easily lifting off with push-pin releases at the rear. The back panel comes off with familiar thumbscrews. The front panel and dust filter pop out, revealing one of Be Quiet!'s Silent Wings 2 fans built into the case—another sits at the back of the unit. For this build, we shifted the rear fan to the front of the case, where there's ample room for multiple fans inside a vertical slot that directs airflow up along the top of the case, and out of fluted exits designed to minimize sound. These fans screw in easily at the front.

To replace the rear fan, we fitted a Silent Wings 3; a slightly smaller model from Be Quiet! that fits in with plastic pins and rubber washers, again to reduce noise. At the bottom, a plastic cover pops out to reveal the drive cage, but as we're not fitting an HDD, it can stay in place.

2

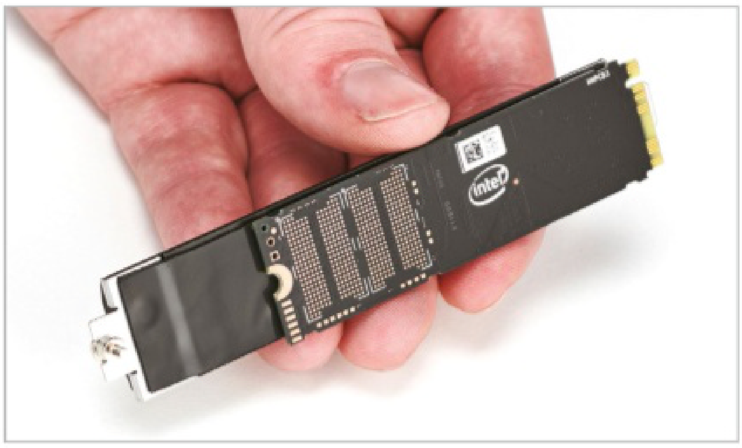
SETTING UP

WITH OUR SILENT CASE PREPARED, it's time to start working on the motherboard. This can be mounted inside the case before you start to add components, because the Silent Base leaves plenty of room to work internally, but the Z370 is somewhat bulky with plastic, so the easier approach is to place it atop its box as an antistatic workbench, and get cracking. The CPU bracket lifts up easily with a conventional metal catch, simply lining up the processor's triangular corner, and locking it back down into place. The RAM comes next. With the clasps opened, the sticks slide satisfyingly into the first and third slots. The Ballistix Sport is a great choice here, thanks to its minimal overhead.

3

HEAT SHIELDS

THE Z370 HAS TWO SLOTS for M.2 drives, but only one has the thermal guard on the 2.0 model. If you're using the regular Aorus Ultra Gaming model, fitting your SSD to the slot further away from the CPU might be wise for future maintenance, as the CPU heatsink will impact accessibility. For now, we simply unscrewed the guard, slotted the drive into place, removed the plastic covering on the guard's sticky pad, and screwed it down on top of the drive. Be precise, as the pad isn't designed for repeat uses—it's liable to come off the thermal guard in pieces if you're not careful. The drive itself doesn't need to be screwed in, although the standoff from the other M.2 slot can be moved over if you want a bit of extra stability. If you like, you can hook up a power supply and monitor to test that everything is functioning correctly at this stage.



4

SCREWED IN

THE NEXT STEP IS TO MOUNT the motherboard inside the case. The interior metal frame of the 601 is quite skeletal and has plenty of room, so the process was relatively straightforward. Slot the I/O shield into place first, then line up the motherboard using the location peg in the center of the case. We had a bit of difficulty with the standoff screws—this case had been used for a previous build when we reviewed it, so we ended up having to replace most of the standoffs. This shouldn't be an issue with a new case, though. The motherboard screws down at eight points; make sure these screws are secure, as they will need to support the weight of a hefty GPU and heatsink. The case has some of its own wiring to contend with, and it's best to get it plugged in now; LEDs for the front I/O and the case's external fan controller.

5

STAYING COOL

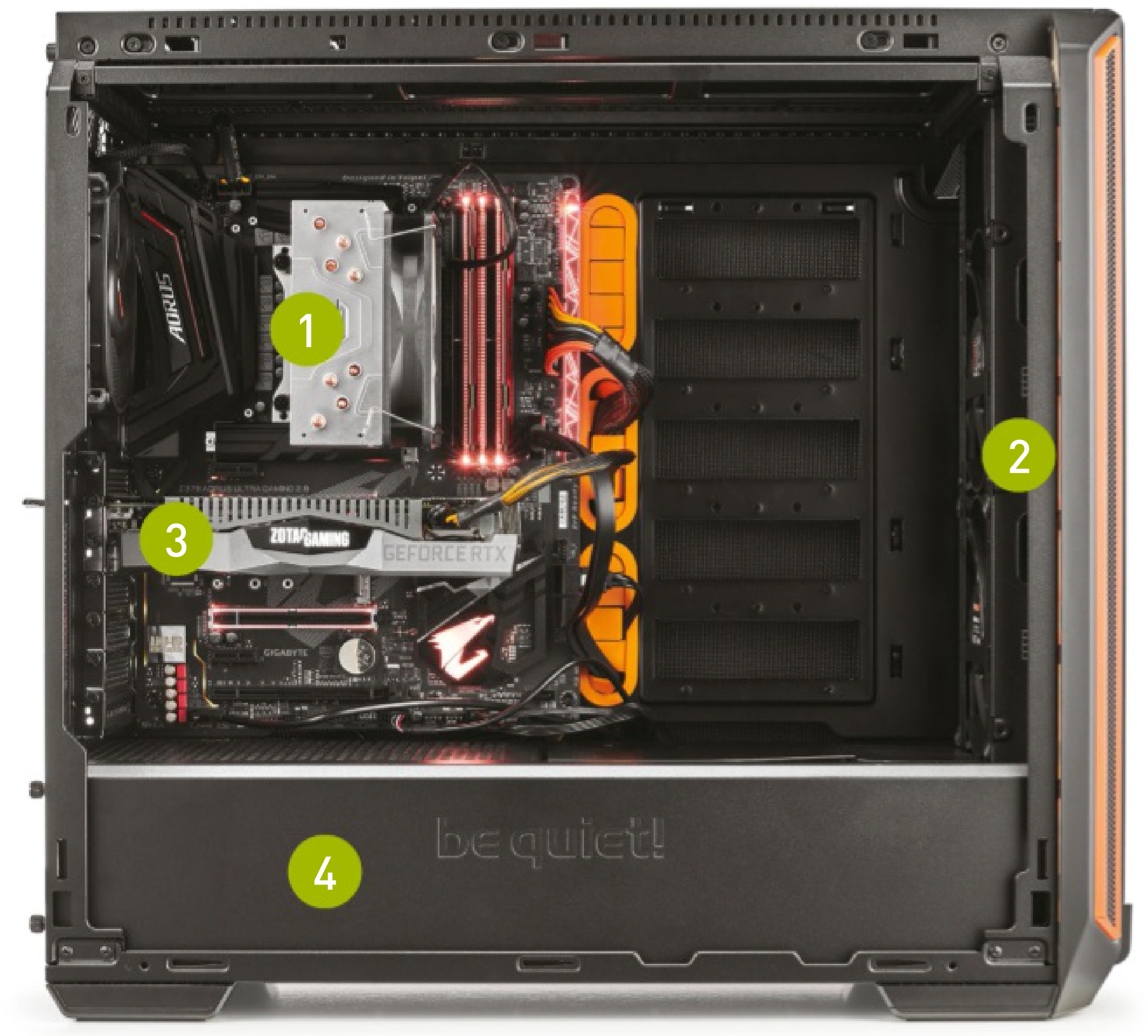
ARGUABLY THE MOST FINICKY PART of any build, the CPU cooler is the next part to fit. This could be done with the motherboard outside the case, but the Freezer 33 is quite heavy, and trying to move the mobo with it attached would be more trouble than it's worth. The Freezer 33 is suitable for both Intel and AMD motherboards, so check that the holes line up before you apply any thermal paste to the processor. This cooler is designed to fit the fan on a specific side, so make sure it's aligned correctly—the fan is best situated on the opposite side to the rear I/O ports, which will direct airflow to the rear of the case. Once ready, apply a small blob of paste, and push the heatsink down gently to spread it. We had a bit of difficulty with the screws here, but ultimately got it screwed down. The wire brackets for the fan slot into small holes at the top and bottom of the heatsink—these are awkward but flex to fit into the holes. Once done, the fan mounts easily.

6

GRAPHIC VIOLENCE

AT LAST, THE GPU can be fitted. This requires the removal of two blanking plates at the rear, but these are easy enough to unscrew. The trickier part is slotting the card into place; the 2060 is weighty, so take care not to drop it and risk damaging your motherboard. Once in the slot, close the clasp on the side of the base, and screw it on to the back panel of the machine. Once the GPU was installed, we connected the PSU, and plugged in the remaining wires, feeding them through the case's rubber-lined slots, and bundling them neatly behind the mobo frame with cable ties. There is ample room behind the PSU to fit any loose cables, and the empty HDD cage to the front of the machine works as well. The final step is to screw the Samsung SSD into place on the back of the frame, and wire it through the to the mobo. For convenience, the motherboard's power supply cable can be fed underneath the SSD cage to keep it out of the way.

ZOTAC GAMING
GEFORCE RTX



1 **Arctic's Freezer 33 cooler is an effective unit, but undeniably a bit clunky. Fitting the wire brackets before screwing down the heatsink may be advisable.**

2 **Including the GPU's integrated cooling, there are six fans in this build. Be Quiet! lives up to its name, though; very little noise escapes this case.**

3 **The Zotac RTX 2060 is the belle of this ball, anchored into the backplate of the casing. The 610 is a huge case, but the 2060 still takes up a lot of room.**

4 **With plenty of space to tuck away cables, this is a tidy build. The power supply fits underneath the case's main cavity at the base, leaving plenty of room for further developing this system later on.**

SILENT RUNNING

AS FIRST BUILDS GO, this was a solid one. The Silent Base 601 is an eminently accessible case, with the finished rig running smoothly and quietly. The fan controller is a clunky switch with three settings, but on the lowest setting, the sound is close to inaudible.

This machine will eventually demand upgrading. Zotac's take on the RTX 2060 is a modern graphics card that will last for a while, and support for ray tracing is a useful addition compared to the less affordable 2070 and 2080 (or the wallet-smashing 2080 Ti). 4K gaming isn't really an option, though, even though the processor can handle such loads. Running on low to medium settings at 60fps is manageable, but not optimal.

For 1080p and 1440p gaming, though, this is a beast. The hex-core 8400 CPU copes well, and the 2060 powered through our benchmark games. This rig isn't going to be doing anything particularly intensive, but seeing games auto-detect to Ultra is always satisfying. Ultimately, there is room for improvement—a relatively budget M.2 drive and cooler mean this build isn't perfect, but it still achieves its goals.

The motherboard is a reliable 2018 release, and we wouldn't personally swap it out from this build, although there is a reasonable argument to be made for the slightly older Z370 Aorus Ultra Gaming. The 2.0 variant handles heat better thanks to the M.2 thermal guard and a different power design that manages overclocking more efficiently, but it has also lost the original's DVI-I port on the rear I/O panel. The price difference is negligible, however.

Rebuilding this machine with a bigger budget, we'd probably opt to bring in more parts from Be Quiet!—one of its coolers would be good, because the noisiest component of this build is almost certainly the lone Arctic fan. Hiking the price up more could mean adding its Silent Loop liquid-cooling system, which features additional Silent Wings 2 fans, but in all honesty, this would be overkill. A Shadow Rock 2 would be a sensible change for only a slight price hike.

The only real loss here is style. The 601 is a good-looking case, but RGB components are worthless due to the solid metal design. It's function over form, making the best of the sound-absorbing padding. For a flashier design, the windowed 601 is necessary. The mobo supports light strips, and the RAM sticks could be replaced by ones with RGB lighting—Geil's EVO X offerings spring to mind. In spite of this, we're extremely pleased with how our rig has turned out. ⏻

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,152	931 (-19%)
CrystalDisk QD32 Sequential Read (MB/s)	3,400	2,778 (-18%)
CrystalDisk QD32 Sequential Write (MB/s)	1,720	1,487 (-14%)
Rise of the Tomb Raider (fps)	60	90 (50%)
Total War: Warhammer II (fps)	46	78 (70%)
Tom Clancy's Ghost Recon Wildlands (fps)	39	61 (56%)
3DMark: Fire Strike (Index)	11,101	15,961 (44%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 1600, 16GB of Crucial Ballistix Sport LT @ 2,666MT/s, an EVGA GeForce GTX 1060 3GB, and a 250GB Samsung 960 Evo M.2 PCIe SSD. All tests were performed at 1080p at the highest graphical profile.

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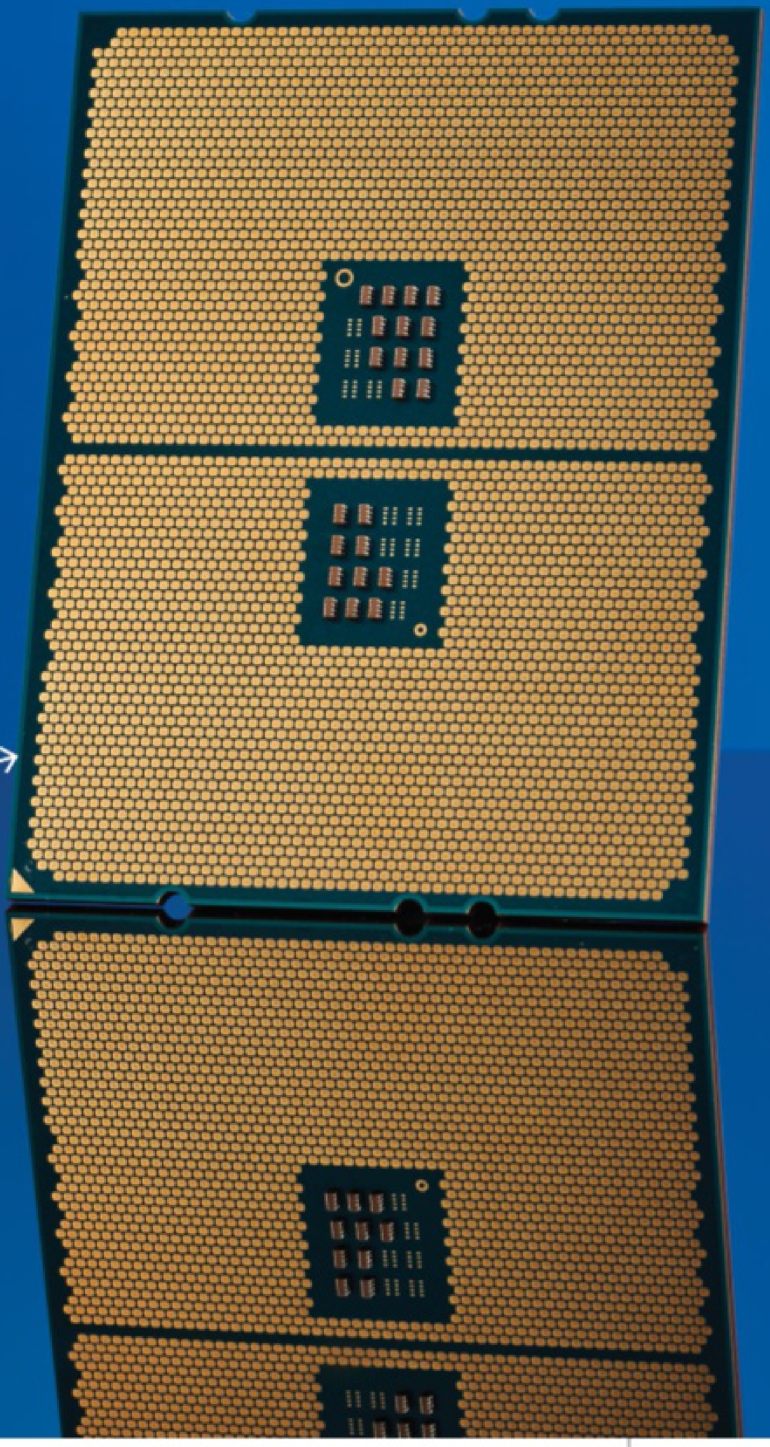

AMD THREADRIPPER 2990WX

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Asus ROG Strix GeForce 1660 Ti 06G

Turing minus ray-tracing and deep-learning bloat

PREDICTING THE FUTURE is tricky: Real-time ray tracing might sound cool, but if it tanks performance, we're fine without. So, half a year after unveiling its Turing architecture, Nvidia is rolling out the mainstream options, minus ray tracing and deep learning. It's everything gamers wanted from Turing, with none of the extra bloat. Say hello to the GTX 1660 Ti.

The new addition to the Turing family is a departure from previous models, as the RT and Tensor cores are gone. In their place you get... actually, you don't get anything. Instead, Nvidia ends up with a smaller, more affordable GPU. You do get the other Turing architecture updates, though, including support for variable rate shading, simultaneous INT and FP operations, rapid FP16 packed math, and improvements in the cache hierarchy.

There are other improvements. Turing GPUs are manufactured using TSMC's 12nm FinFET process, and so far all of the GPUs use GDDR6 memory. The GTX 1660 Ti does drop the memory speed to 12Gb/s (compared to 14Gb/s on RTX cards), which makes us wonder how much memory overclocking headroom remains.

The GTX 1660 Ti sticks close to the GTX 1060 6GB price while increasing most of the specs. It has 20 percent more CUDA cores, a 50 percent increase in memory bandwidth thanks to GDDR6, and slightly higher clock speeds that should mean 25 percent better theoretical performance.

As far as the cards go, Nvidia isn't providing a reference design. There are plenty of GTX 1660 Ti models available from the usual AIB partners, running from reference clocks to uber-clocked models, and Asus was the first AIB partner to get us a GTX 1660 Ti sample.

The ROG Strix GTX 1660 Ti 06G is a halo card, with a price to match. At $330, this is considerably more than the $280 you can get more stripped-back versions of the card for, but you do get triple fans, addressable RGB lighting, dual BIOS, and a factory overclock to 1,890MHz for the boost clock (1,530MHz base clock).

While you could argue that $280 is not really a mainstream price either, the GTX 1660 Ti clearly targets 1080p gamers. And the news is good: At 1080p, the GTX 1660 Ti zips along, and averages well above 60fps in most, if not all, games. Where does it come up short? Not surprisingly, it's the most demanding games: *Anthem, Assassin's Creed Odyssey,* and *Metro Exodus* can't quite maintain a steady 60fps at 1080p ultra. You'll want to drop settings down a notch or two in such cases, but at 1080p medium, there's still plenty of headroom left.

If you're sitting on an older GPU, such as a GTX 970, this is an upgrade worth making: Performance is 75 percent better at 1080p ultra, as well as 55 percent faster at 1080p medium. Of course, anything slower than a 970 would see even bigger gains. Compared to AMD's R9 390, the 1660 Ti is 65 percent faster, while cutting the graphics card power use in half. Still, it would be a much more noticeable

BENCHMARKS

	Asus ROG Strix GeForce 1660 Ti 06G	Nvidia GeForce GTX 1070
Assassin's Creed Origins (Avg fps)	**75/58**	72/54
Deus Ex: Mankind Divided (Avg fps)	**63/43**	**63/43**
Far Cry 5 (Avg fps)	98/68	**101/70**
Grand Theft Auto 5 (Avg fps)	**78/54**	77/**54**
Middle Earth: Shadow of War (Avg fps)	**77**/49	74/**50**
Rise of the Tomb Raider (Avg fps)	71/50	**73/54**
Total War: Warhammer II (Avg fps)	76/56	**86/61**

Best scores are in bold. Our test bed consists of an Intel Core i7-7800K, 16GB of G.Skill DDR4-3200, a Gigabyte Z370 Aorus Gaming 7, and a 1TB Samsung 970 Evo M.2. All games are tested at their highest graphical profile with AA turned up, at 1080p and 1440p.

upgrade if you're running something like an HD 7970/R9 280X or lower.

In terms of value, the GTX 1660 Ti sits near the top of the mid-range graphics card pile—depending on the model, naturally. For the GPU in isolation, you could still argue that the RX 580 8GB and RX 570 4GB are better choices, which makes sense, considering they cost 30 percent and 50 percent less, respectively. But the GTX 1660 Ti holds its own against the GTX 1060 cards, never mind the more expensive RTX models. Flip over to a complete mainstream build, and the GTX 1660 Ti looks a lot more promising.

If you're looking to build a new mid-range gaming PC, capable of running nearly any game at 1080p ultra with high frame rates, the GTX 1660 Ti belongs near the top of your list. It easily outperforms Nvidia's old GTX 1060 cards, and doesn't cost much more. It delivers good performance and excellent efficiency, with a price that can reach a much wider audience than the RTX line. It also does a better job at hitting 60fps or more at 1080p ultra, something that the RX 570/580 and GTX 1060 cards can struggle to do, especially on the most recent games. Those looking for something to last a few years while we wait for more capable ray-tracing hardware (hopefully at mainstream prices) will find a lot to like in the GTX 1660 Ti. –**JARRED WALTON**

VERDICT
9

Asus ROG Strix GeForce 1660 Ti 06G

+ **FOCUSED** Cuts the cruft; efficient and overclockable; good balance.

− **BLURRY** Only ties the GTX 1070; RTX 2060 doesn't cost much more; what, only 12nm?

$330, www.asus.com

The GeForce GTX 1660 Ti keeps the Turing architecture, but jettisons the bloat.

SPECIFICATIONS

GPU	Turing TU116
Lithography	TSMC 12nm FinFET
Transistor Count	6.6 billion
CUDA Cores	1,536
Texture Units	96
ROPs	48
Core/Boost Clock	1,530/1,830MHz
Memory Capacity & Type	6GB GDDR6
Memory Speed	12GT/s
Memory Bus	192-bit
TDP	120W
Display Connectors	2x DisplayPort 1.4, 2x HDMI 2.0b

Xidax X-6

X marks the spot

GAMING PCS COME in all shapes and sizes. There's small and compact systems, with minimalist, understated design. And then there's big, hulking machines that command the presence of a room, dazzling with their glowing lights and imposing stature. The Xidax X-6 fits on to the latter half of that spectrum.

Let's start with the outside. The X-6 we tested uses Be Quiet!'s Dark Base 700 case, which features large smoky tempered glass panels and *Tron*-like lights adorning the front. The system is big—21.5 x 9.5 x 20.5 inches—and relatively understated considering the gleaming lights on the front. This is somewhat due to the smoky, semi-translucence of the panels, which give a shadowy look at the glowing components inside—namely the MSI RTX 2080 Gaming X Trio GPU, G.Skill Trident Z RAM, and Corsair 120mm LL RGB fans, all of which gleam with a rainbow of RGB lighting.

The backbone of the X-6's internals is an MSI MEG Z390 Ace mobo, paired with an Intel Core i7-8700K processor. For storage, a 500GB Xidax Performance NVMe SSD pairs with a 1TB Western Digital Blue 7200 rpm HDD. We already mentioned the GPU, RAM (16GB, 3,200MHz), and fans. Rounding things out is an AlphaCool Eisbaer 360mm AIO liquid cooler and 850W Corsair PSU. And to make everything look clean, Xidax has used uni-sleeved black and white cables.

The case design is solid, though accessing the internals requires unscrewing thumbscrews (thankfully no screwdriver required) and removing the glass panel. It's not the worst method of access, but less convenient than the magnetic doors found on some premium builds. Inside, the white-sleeved cables elegantly accent the RGB lights found on the three radiator fans up top, the Trident Z RGB RAM, and the MSI Gaming X GPU itself, which is held up by a support bracket that we mistook for a second GPU in SLI at first glance.

KEEPING SCORE

The Xidax X-6 performed as expected for a system with a Core i7-8700K and RTX 2080 in our gaming benchmarks. At 1080p ultra, our demanding set of games easily stayed above 100fps except in the case of the super-punishing *Ghost Recon: Wildlands*, which averaged 76fps on the in-game benchmark. *Shadow of the Tomb Raider* returned a score of 116fps, while *Total War: Warhammer II* scored 104fps. Finally, the X-6 scored 21,573 in 3DMark Fire Strike.

Moving up to 1440p ultra, the system still managed to stay above 60fps in all three games, though at 4K the scores dropped to the 38–43fps range. These are, of course, scores for extremely demanding games and using the highest available in-game preset, so gaming at 1440p or 4K is entirely doable on the X-6 if you don't mind dropping a few settings. 3DMark Fire Strike Ultra 1440p scored 12,166, while 4K scored 6,439.

While everything about the X-6 screams gaming machine, it scored admirably in productivity benchmarks as well. Cinebench R15 scored 1,386 in multithreaded performance, and 191 for single-thread. Storage performance was solid, too: 1,706/781 in CrystalDisk QD32 Sequential Read/Write. Finally, it scored 5,031 in PCMark 10 Express.

Of course, all that performance comes with a hefty price tag. The X-6 costs $3,059 for the configuration we tested, while you could assemble a near-identical system for less than $2,500 by buying the parts individually and building it yourself. What you get for that extra $500 is the cost of assembly—which looks fantastic, thanks to all the custom cable sleeving—and, more importantly, Xidax's lifetime warranty on parts and service. There are lower (and higher) priced configs of the X-6, but they all come with the same lifetime warranty. That's an impressive guarantee, and absolutely worth considering if you're in the market for a new prebuilt gaming PC. **–BO MOORE**

VERDICT **9**

Xidax X-6

⊕ **BURIED TREASURE** Beautiful, clean design; lifetime warranty.

⊖ **WALK THE PLANK** Expensive; struggles at 4K Ultra.

$3,059, www.xidax.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,152	1,386 (20%)
CrystalDisk QD32 Sequential Read (MB/s)	3,400	1,706 (-50%)
CrystalDisk QD32 Sequential Write (MB/s)	1,720	781 (-55%)
3DMark Fire Strike (Index)	11,101	21,573 (94%)
Rise of the Tomb Raider (fps)	60	116 (93%)
Total War: Warhammer II (fps)	46	104 (126%)
Tom Clancy's Ghost Recon: Wildlands (fps)	39	76 (95%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point consists of an AMD Ryzen 5 1600, 16GB of Crucial Ballistix Sport LT @ 2,666, an EVGA GeForce GTX 1060 3GB, and a 250GB Samsung 960 Evo M.2 PCIe SSD. All tests were performed at 1080p at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i7-8700K
Graphics	MSI RTX 2080 Gaming X Trio
RAM	16GB G.Skill Trident Z DDR4-3200
Motherboard	MSI MEG Z390 Ace
Primary Storage	500GB Xidax Performance NVMe M.2 SSD
Additional Storage	1TB WD Blue 3.5-inch 7200 rpm HDD
Cooling Solution	AlphaCool Eisbaer 360mm AIO liquid cooler
PSU	Corsair RM850
Case	Be Quiet! Dark Base 700
Warranty	Lifetime parts and labor

The Xidax X-6 performs as expected for its price and specs, and that's not a bad thing.

AMD Threadripper 2990WX

Too many cores! Too many cores!

YEAH, AMD'S WON. Let's just leave it at that, shall we? 32 cores and 64 threads in a mainstream processor. If there ever was a core war, it's surely done with now. At least as far as the consumer market's concerned, anyway. Honestly, this thing is just crazy. It houses 64MB of L3 cache, 16MB of L2 cache, and 3MB of L1 cache, and comes with a base clock of 3GHz, boosting up to 4.2GHz on a single core as and when needed. Couple that with an insanely low 250W TDP and a $1,730 price tag, and we're done—what else is there to say?

Seriously, Intel's best bet against this gargantuan part is its "mainstream" Xeon W-3175X. You know, the 28-core chip that comes in at $3,175. And that's not even taking into account the fact that the only mobo that currently supports it costs an additional $1,800. If this is a numbers game, AMD has won, not only on value, but on cores. And, boy, does it show. The old blue dog has fallen.

But let's not kid ourselves: These processors aren't for a second to be considered gaming parts. Neither Intel's rebadged Skylake Xeon nor AMD's 2990WX are designed with that in mind. They'll do it—we're not saying they won't—but you'd be far better off with an Intel Core i9-9900K, or something with a sensible architectural design over either of these two beasts.

So, what's so problematic about the 2990WX? Well, it's how the memory channels are delivered to the processor. Each of these processors comes with four individual Ryzen dies connected together with AMD's never-unimpressive Infinity Fabric. Each core complex, housing eight cores, communicates with one another across this fabric. However, only two core complexes have direct access to the memory channels. The other two have to piggyback across for their memory requests. This introduces latency, and we're talking a lot of it, too. Although not an issue in enterprise and server-grade software, in the land of gaming, that latency means frame rate drops and all manner of nastiness. In fact, AMD recommends that if you do want to game on this beast, you jump into the Ryzen Master software, and enable Game Mode instead of the default Creator Mode. This disables the two core complexes that don't have access to the memory channels as standard, allowing for far better gameplay results. And it really makes a difference—we're talking double the average frame rates. Don't get overly excited, though, because that doubling merely brings them in line with what you would expect from any other non-WX processor.

That aside, this chip is nothing short of incredible when it comes to workstation and rendering applications. Or at least, those that actually support more than 32 threads. In Cinebench R15 alone, at stock we achieved a score of 5,195, and pushed past 6,000 with a fairly mild overclock. That's just mad, and puts it leaps and bounds ahead of anything we've tested in the past. Even single-core isn't too shabby, pulling in a steady 173. Alas, that's about the only benchmark we can report on, because the rest of our testing suite just doesn't support more than 32 threads, as you'll spot below.

Threadripper has always been an insanity-inducing part. It's not really ever been something taken too seriously by AMD. Its uses vary depending on who's buying. For the vast majority of smart buyers out there, these will find good homes in the ray-tracing studios and CAD/CAM workhouses of the world. For everyone else, it's all about the epeen—but that doesn't make a good purchase. If you need the cores, this thing is the absolute king of processors, and it shouldn't even really exist outside of the realms of the server. Ah, hell, we love it anyway. **–ZAK STOREY**

BENCHMARKS

	AMD Threadripper 2990WX	AMD Threadripper 2970WX	Intel Core i9-7980XE
Cinebench R15 Single (Index)	173	172	**194**
Cinebench R15 Multi (Index)	**5,195**	4,407	3,405
Tech ARP's X264 (Avg fps)	**94.81**	81.04	69.18
Fry Render (m:s)	1:21	1:20	**1:10**
AIDA64 Memory Latency (ns)	**68**	**68**	69
AIDA64 Memory Bandwidth (MB/s)	76,032	75,967	**90,654**
Power Draw Idle/Load (Watts)	**74**/331	88/324	91/**252**
Total War: Warhammer II (fps)	74	74	**80**
Ghost Recon Wildlands (fps)	57	57	**61**
Middle Earth: Shadow of War (fps)	92	92	**98**
3DMark Fire Strike (Index)	15,731	15,476	**19,491**
Maximum Overclock @ Voltage (GHz @ V)	4.1 @ 1.44	4.1 @ 1.43	**4.2 @ Auto**
Price to Performance (Index)	3.0	**3.44**	1.66

Best scores are in bold. Our test bed consists of an Asus ROG Zenith Extreme, 32GB of G.Skill Trident Z DDR4, an Nvidia GeForce GTX 1080, and a 500GB Samsung 970 Evo. All games were tested at 1080p on the highest graphical profile, with average fps noted.

VERDICT 9 KICK ASS!

AMD Threadripper 2990WX

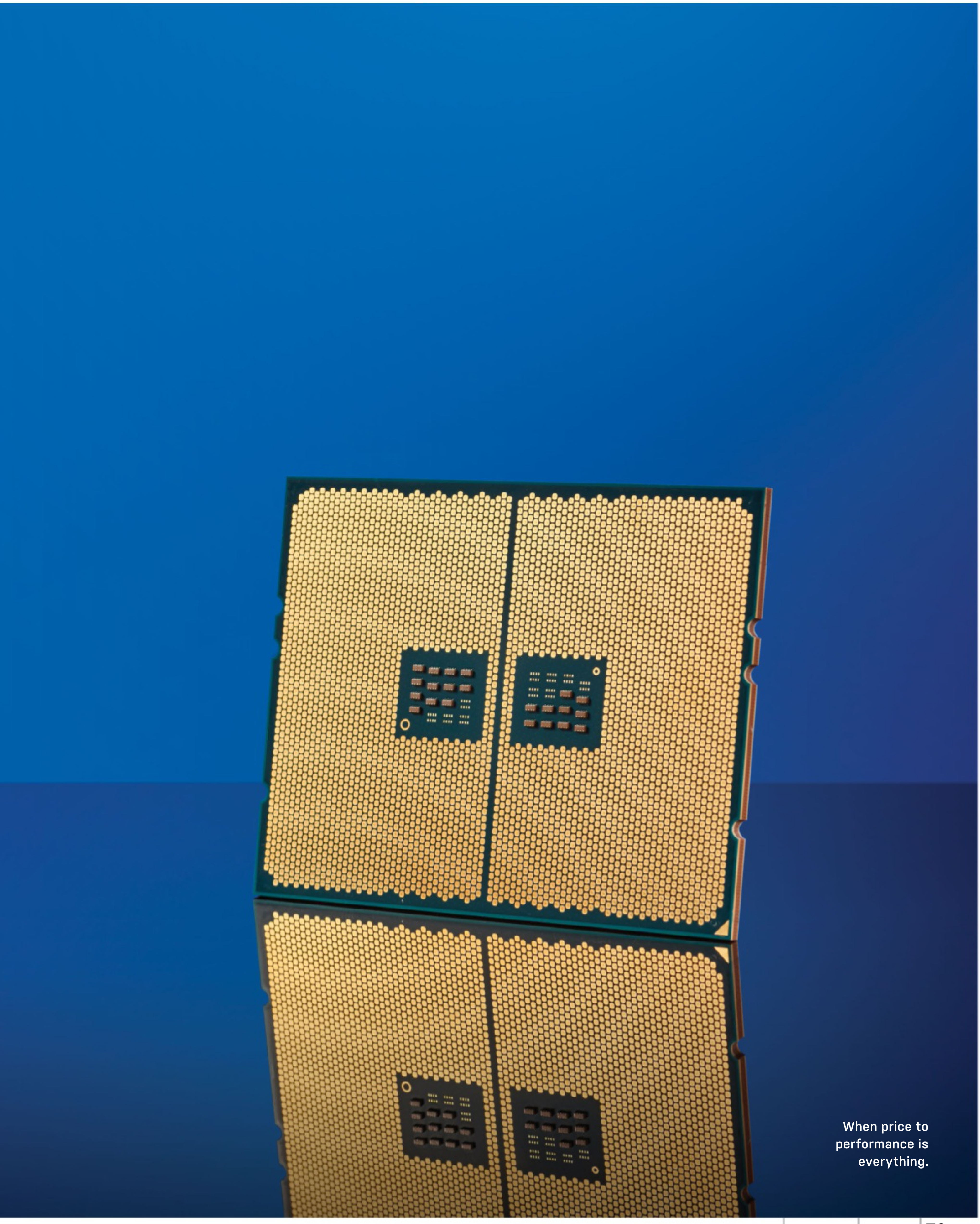
+ **RAGNARÖK** Incredible price to performance; crazy core count; impressive overclocking guts and temperatures.

− **RAGS & ROCKS** Still expensive; likes some power.

$1,730, www.amd.com

SPECIFICATIONS

Base/Turbo Clock	3.0/4.2GHz
Cores/Threads	32/64
Lithography	12nm
Cache	L3 64MB
Memory Support	128GB DDR4
Memory Channels	4
Max PCIe Lanes	64
TDP	250W



When price to
performance is
everything.

Asus ROG Zephyrus S GX701GX

Asus updates its ultra-slim gaming portable to 17 inches and RTX graphics

THE ORIGINAL ASUS ROG Zephyrus was an intriguing portable gaming rig. At the time, it was the slimmest gaming laptop to offer Nvidia's top GeForce GTX 1080 graphics. That was thanks to a novel hinged cooling solution that opened out as you raised the screen lid. Clever.

Less brilliant was the relatively big bezel around the 15.6-inch LCD panel, which undermined the Zephyrus's low-profile pretensions. No longer. For the new Asus ROG Zephyrus S, that bezel has been massively minimized. The result? You get a 17.3-inch display in a chassis that's only a tiny bit bigger than before.

The other ROG Zephyrus attractions largely endure, including the funky cooling, the forward-located keyboard, side-mounted trackpad, magnesium-alloy body, a powerful CPU, and cutting-edge graphics, the latter updated to the latest GeForce RTX 2080 GPU. The result splits opinion, but it's certainly a high-quality bit of gear that carves out a unique niche in the gaming laptop segment.

Exactly how successful it is overall, well, that's an interesting question. The chassis design is a win in terms of proportions. This is an incredibly sleek and slim laptop for a 17-incher with high-end graphics. The keyboard and trackpad are an acquired taste; one of those things you have to try for yourself. But the feel and quality are great, that's for sure.

As for that unusual cooling solution, it's hard to know how much benefit it brings. What we can say is that the RTX 2080 graphics is clocked at 1,230MHz boost. That's a fair distance off the 1,590MHz clock of the fastest laptop implementations of the RTX 2080, let alone the 1,800MHz of the RTX 2080 in desktop Founders Edition specification. For the Zephyrus, of course, Asus selected the low-power Max-Q variant. Long story short, there's a clear trade-off in terms of GPU performance in return for the slim chassis proportions.

The CPU side of the equation is a little more straightforward, with the Intel Core i7-8750H six-core processor and its 2.2GHz base clock and 4.1GHz Turbo clock very much a known quantity. It's one hell of a mobile CPU.

Elsewhere, the spec list is pretty impressive. The 17.3-inch screen packs IPS technology, 144Hz refresh, 3ms responses, and G-Sync adaptive refresh (note the latter requires a full reboot to enable, and does bad things for the already mediocre battery life). The SSD is a 1TB Samsung PM981 M.2 drive, which is more or less an OEM version of the 970 Evo, and there's fully 24GB of RAM.

As for the actual user experience, it's mostly great. Gaming performance from that RTX 2080 GPU is very nice indeed, even if the reined in clock speeds peg frame rates back noticeably versus a desktop RTX 2080. The screen is mostly impressive, with accurate colors and reasonable contrast to go with the slick 144Hz refresh. If there is a disappointment, it's the relative lack of punch and brightness. A stronger backlight would be welcome.

If you demand further demerits, the trackpad feels puny in this age of outsized alternatives, and you're looking at a little over three hours of battery life with the screen set to half brightness when watching movies. If that doesn't sound great, use this laptop anywhere other than a dark environment, and you'll want to crank the screen up beyond 50 percent brightness. The real-world impact on battery life on bumping the brightness up will only make things worse.

But then that probably isn't part of the core remit for the Zephyrus S. If you want great gaming performance in a quality package that's reasonably portable, this thing is pretty hot. Unfortunately, so is its $3,299 sticker price. Ouch. –**JEREMY LAIRD**

VERDICT

8

Asus ROG Zephyrus S GX701GX

➕ SIZE MATTERS Bigger 17.3-inch screen, same sleek proportions; Nvidia RTX graphics update.

➖ LESS ISN'T MORE Slim chassis limits GPU clock speeds; very, very expensive.

$3,299, www.asus.com

BENCHMARKS

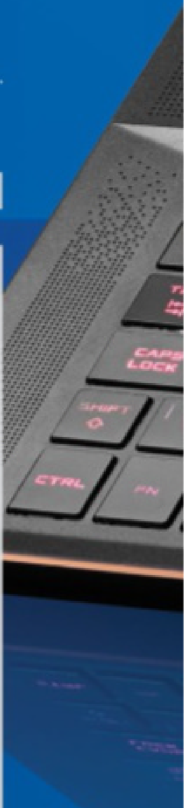
	ZERO-POINT	
Cinebench R15 Multi (Index)	743	1,212 (63%)
CrystalDisk QD32 Sequential Read (MB/s)	563	3,079 (447%)
CrystalDisk QD32 Sequential Write (MB/s)	133	2,379 (1,689%)
3DMark: Fire Strike (Index)	13,202	17,688 (34%)
Rise of the Tomb Raider (fps)	99	109 (10%)
Total War: Warhammer II (fps)	62	72 (16%)
Tom Clancy's Ghost Recon: Wildlands (fps)	48	58 (21%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero-point is the Asus GL502VS-DS71, with an Intel Core i7-7700HQ CPU, an 8GB GTX 1070, and 16GB of DDR4. All game tests are performed at 1080p and the highest graphical profile.

SPECIFICATIONS

CPU	Intel Core i7-8750H
Graphics	Nvidia GeForce RTX 1080
RAM	24GB DDR4
Screen	17.3-inch, 144Hz, 3ms
Storage	1TB M.2 SSD
Ports	USB-C, 4x USB 3, Mini DisplayPort, HDMI, audio, SD reader
Connectivity	LAN, Intel ac gigabit Wi-Fi, Bluetooth 5.0
Weight	5.95lb
Size	15.7 x 10.7 x 0.7 inches



NVIDIA
G-SYNC
144HZ
3ms
PANTONE
Hi-Res
AUDIO
ROG ZEPHYRUS

The Zephyrus S squeezes a 17-inch panel into a similar chassis as the old 15-inch model.

ZENITH
REPUBLIC OF GAMERS

The pinnacle of Threadripper's potential.

Asus ROG Zenith Extreme Alpha

Flagships reimagined

WE'RE IN TWO MINDS about the Alpha. In some ways, it's a fantastic board, worthy of high praise. It takes feature sets found in some of the best Asus motherboards and applies that same logic to an X399 setup that seriously scuppers the rest of the competition. Whether you're talking about its extensive VRM cooling, the fantastically clean-looking rear I/O cover and armored PCB shielding, the PCIe layout, or the extensive M.2 connectivity, it's a true beast of a motherboard.

The thing is, in our eyes, this X399 board only exists because the original Zenith Extreme wasn't good enough. Indeed, if you wanted to throw in a WX-edition second-generation Threadripper, the VRMs wouldn't be able to cope with all those additional cores. Let's face it, that's embarrassing for a flagship product, especially one in a product stack and chipset that's not going to see any new releases until at least third-gen Ryzen and DDR5. In fact, Asus would send you an additional heatsink for free to install on your Zenith Extreme to help cope with the additional legwork those VRMs would be doing with a 24-core part or more.

On the flip side, the Alpha is also cousin to the Asus ROG Rampage VI Extreme Omega, an X299 motherboard redeveloped specifically for Intel's Skylake-X product stack, including the divisive Intel Core i9-9980XE. Both boards feature similar designs, similar I/Os, and almost identical connectivity—it's all there. And again, all on chipsets that haven't seen an update for some time. The Alpha and the Omega. It's an interesting concept, that's for sure, if not a little brash in the naming scheme.

FANTASTIC FEATURES

Moving on, let's list some of the Zenith's specs: 4x PCIe 3.0 x16 slots (for up to x16x8x16x8); 1x PCIe 3.0 x4 slot (for PCIe SSD add-in cards, particularly useful for our 905P in DM); quad-channel memory, of course, up to 3,600MT/s (only 3,000MT/s if you want 128GB); eight SATA 6Gb/s ports; and support for three M.2 PCIe SSDs. You also get an Aquantia AQC-107 10Gb LAN port, a kick-ass audio setup, and a whole swathe of other intuitive features. Our favorites include the OLED display on the rear I/O to diagnose errors and display temperature, the on-board power on and reset buttons, and the 12 USB 3.1 ports.

Yeah, this thing is pretty nuts. In fact, that OLED display alone is worth its weight in gold when it comes to the value of this board. Of course, you also get a BIOS debug code indicator, but the display tells you there and then what the problem is—"0D Memory Detect," for example (the code burned into this reviewer's brain on his first Zenith Extreme Alpha sample)—which does save time when it comes to diagnosing what exactly is wrong with your rig, if anything.

Performance is exactly where you'd expect it to be, certainly at stock, anyway. It's an X399 motherboard, and it does particularly well with our AMD Threadripper 2950X, with a complement of 32GB of Corsair Dominator Platinum. You can expect overly strong figures in Cinebench R15 and PC Mark (although there are options to disable those tweaks in the BIOS), and slightly higher thermals than you'd expect if you ran it completely stock. Asus's BIOS is a pretty sight nowadays, and very much a mature platform; any and every option you could want is easy to find and access, making the whole thing an exceptionally enjoyable experience.

The Zenith Extreme Alpha really is a tale of two cities. On the one hand, it shouldn't even exist—if the original Zenith Extreme had been designed with the larger processors in mind from the get-go (something *Maximum PC* predicted on the launch of the original Threadrippers), an update wouldn't have been necessary. On the other hand? Well, we're darn glad it does exist, that's for sure. It encapsulates everything we want from a high-end motherboard, and despite the price, it truly is the pinnacle of what you'd want to see from a flagship product such as this. **–ZAK STOREY**

BENCHMARKS

	Asus ROG Zenith Extreme Alpha	MSI MEG X399 Creation
Tech ARP's X264 (fps)	**68.63**	68.51
Cinebench R15 Multi (Index)	**3,271**	3,259
Fry Render (m:s)	**1:20**	**1:20**
AIDA64 Memory Latency (ns)	**67.7**	89.6
CrystalDisk QD32 Sequential Read (MB/s)	**1,862**	1,857
CrystalDisk QD32 Sequential Write (MB/s)	**1,701**	1,695
Power Draw Idle/Load (Watts)	71/342	**70/299**
Total War: Warhammer II (fps)	**76**	**76**
Lowest Voltage @ 4.0GHz (Volts)	1.14	**1.13**
Maximum OC Achieved (GHz)	**4.2**	**4.2**

Best scores are in bold. Our test bed consists of an AMD Threadripper 2950X, 32GB of Corsair Dominator Platinum DDR4 @ 3,200MT/s, an Nvidia GeForce GTX 1080, and a 250GB Samsung 850 Evo. *Total War: Warhammer II* was performed on the Ultra preset at 1440p.

VERDICT
9
KICK ASS!

Asus ROG Zenith Extreme Alpha

➕ **NUMERO UNO** Impeccable performance; feature set is huge; OLED display incredibly useful; good VRM cooling; strong overclocking.

➖ **ALPACA EDITION** A touch pricey; RGB software currently AWOL.

$650, www.asus.com

SPECIFICATIONS

Chipset/Socket	X399/sTR4
Form Factor	E-ATX
Memory Support	128GB @ 3,000MT/s; 64GB @ 3,600MT/s (ECC DDR4)
M.2/U.2 Support	3x M.2 PCIe 3.0
SATA Support	8x SATA 6Gb/s
Max PCIe Support	4x PCIe 3.0 (x16x8x16x8)
Rear I/O	11x USB 3.1 Type A, 1x USB 3.1 Type C, Aquantia 10Gb Ethernet, Intel Gigabit Ethernet, 5.1 audio, optical audio out, wireless A/C, BIOS reset, CMOS clear

Philips Brilliance 499P9H

Taking superwide to the next level

DRAWING A CROWD in the Maximum PC office takes a special piece of hardware. The problem is, we've seen it all before. So, it's a measure of the sheer visual drama delivered by Philips's new 49-inch monitor that it brought proceedings to a standstill. Everyone had to stop and look.

The Philips Brilliance 499P9H is not actually the first 49-inch panel on the market to offer that crazy 32:9 aspect ratio—Samsung has done it already—but Philips has upped the ante in terms of pixel count. Where Samsung's 49-inchers topped out at 3,840 across and a mere 1,080 vertical pixels, the 499P9H clocks in at 5120x1440. That's a very useful uptick in vertical resolution, and immediately offsets the main objection faced by the Samsung alternatives.

Sheer scale and resolution aside, the 499P9H has a few more tricks up its extremely long sleeves. For starters, there's a built-in USB Type-C docking solution, offering the usual cable-minimizing single-cord connectivity, so you can charge a laptop, drive the display, and forward some USB ports to the screen with a single cable. To that Philips has added an RJ-45 Ethernet port, ensuring a very comprehensive docking setup.

While we're on the subject of simplified connectivity, the 499P9H also comes with a built-in KVM, so you can control two PCs with one monitor-keyboard-mouse setup. A handy button enables you to make the jump between machines more or less instantly. Another useful extra is the pop-up webcam integrated into the top of the display, with full support for Windows Hello facial recognition.

But what of that insane 49-inch panel? It's DisplayHDR 400 certified, but as we've discussed previously, that's the very bottom rung of HDR capability. It doesn't require local dimming, and only dictates a maximum brightness of 400cd/m^2. Not the stuff of a true HDR experience.

That said, Philips has gone for VA panel technology, which typically offers vibrant colors and tons of contrast, the latter hinted at by the 3,000:1 static contrast

A 21:9 aspect ratio once seemed insane, so maybe 32:9 isn't so crazy after all....

ratio. So it proves in practice. This panel is plenty punchy. Indeed, the overall image quality is a general plus point, with lots of detail in black and white scale test images, and nice smooth gradients.

The exception, objectively speaking, would be the viewing angles, which aren't entirely competitive with the best IPS monitors. We're not talking about a major performance shortfall, but given the huge size of this display, the slight color deviation is a minor issue at the extremities, even with the 1800r curvature helping minimize the problem.

Ergonomics is the other question mark. What's this thing actually like to sit in front of and use? Actually, rather beguiling. OK, it looks ridiculous at first. And there's no doubting that mousing around such a wide display can feel labor-intensive. But the ability to run so many documents, applications, or web browsers in parallel definitely creates new opportunities in a productivity context. What's more, the modest pixel pitch means you can run the 499P9H at 100 percent scaling while maintaining legibility. Just don't expect high-DPI precision and fonts.

As for gaming, your mileage will vary. The overall pixel count is actually slightly below that of a 4K monitor, and the refresh is limited to 60Hz, so the GPU load isn't preposterous. Plus, the visual impact is totally seductive and immersive. Just bear in mind that a lot of games opt to stretch your field of view at the edges, rather than actually widen it. For competitive online games, it really has to be that way to prevent superwide screen users gaining an unfair edge.

So, the Brilliance 499P9H is definitely a grower. What seems pretty silly at first quickly begins to make a kind of sense. But it remains an extreme solution to the problem of a PC monitor. If you want superwide, 21:9 is probably a better overall compromise. –**JEREMY LAIRD**

VERDICT

8

Philips Brilliance 499P9H

⊞ **BIG PICTURE** Good panel quality; interesting for productivity; nice extras.

⊟ **NARROW VIEW** Vertical resolution still isn't spectacular, especially for the money.

$1,100, www.usa.philips.com

SPECIFICATIONS

Panel Size	49-inch
Native Resolution	5120x1440
Pixel Density	109 ppi
Panel Type	VA
Maximum Refresh	60Hz
Response	5ms
Contrast	3,000:1
Display Inputs	HDMI, DisplayPort, USB-C
Connectivity	USB Type-C, RJ-45
VESA Mount	100 x 100mm
Warranty	Three years

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AMD Athlon 240GE

Tempting if you're on the tightest of budgets, with one major caveat

AMD Athlon 240GE
YD240GC6M20FB
AN 1849PGS
9HG0268X80013
AMD
© 2016 AMD
DIFFUSED IN USA
MADE IN MALAYSIA

YOU'RE SPOILED FOR CHOICE when it comes to high-end and mid-range processors right now, but people on a somewhat tighter budget aren't quite so well catered for. There are numerous reasons for this, some of which are down to technical limitations of the underlying architecture, while others are due purely to marketing decisions. So, what does this Athlon 240GE from AMD bring to the party? And is it a chip you should be considering when you don't have a huge pile of cash?

Before we really get started, there's one aspect of this chip that needs flagging before going any further, and it could well put you off before we really begin: It offers up just eight PCIe lanes for your graphics card. This is due to the integrated Vega 3 graphics grabbing the other half of the usual x16 lanes. It's an important proviso, because despite the protestations that there should be plenty of bandwidth to spare, in truth it has a clear and stark impact on the performance of any discrete graphics card you decide to attach (the Core i3-8100 in the benchmark table below has the full complement of lanes by comparison). Anyone looking to build a cheap base for a gaming PC is going to want to look to a chip with a full-fat PCIe interface, basically.

Now that you've been warned about the main limitation of this APU, you are much better placed to assess what it does bring to the table in a fairer light. Your $80 nets you a dual-core, quad-thread processor that runs at 3.5GHz. This is a 300MHz boost over the otherwise identical $55 Athlon 200GE that we looked at back in the January issue. There's no turbo boost to speak of here, so that 3.5GHz is your lot, but it does give you a decent amount of single and multicore performance to play with. Still, if you're really pursuing that performance goal, then you're going to have to pay considerably more than this to get a chip that can tear up the benchmarks.

That said, this is a low-power chip, with a low, low TDP of just 35W. The bundled cooler highlights this aspect succinctly, measuring just a couple of inches high, and featuring a fan that stays quiet even under full CPU load. In fact, under load, our whole test system (which includes a GeForce GTX 1080) draws just 83W from the wall. If you're looking to use this in a media machine, NAS, or other kind of always-on server, there's a lot to like from those figures alone.

The integrated graphics are pretty good, too. It's true that you're not going to be playing *Apex Legends* on this chip, but there are plenty of older games for which you should be able to tweak the settings. More importantly, this means you don't need a discrete card—which opens up plenty of build opportunities for a variety of smaller, more efficient machines.

The main problem for the Athlon 240GE is that a lot of these positives can be applied to the more affordable Athlon 200GE, and while there is a tad more performance on offer here, it isn't enough to make us want to rush out and get this over that chip. And if you're looking for real power, you're going to have to step up to a Ryzen or an Intel Core i3, which has all those juicy PCIe lanes, potentially more cores, and higher single-core performance to boot. It's not bad, just a little unfocused. **–ALAN DEXTER**

BENCHMARKS

	AMD Athlon 240GE	AMD Athlon 200GE	Intel Core i3-8100
Cinebench R15 Single (Index)	138	121	**153**
Cinebench R15 Multi (Index)	390	348	**598**
Tech ARP's X264 (Avg fps)	8.11	7.81	**14.76**
Fry Render (m:s)	10:39	11.57	**07:28**
AIDA64 Latency (ns)	82.4	84.1	**63**
AIDA64 Memory Bandwidth (MB/s)	38,470	37,859	**42,076**
Power Draw Idle/Load (W)	49/83	44/**67**	**43**/112
Total War: Warhammer II (Avg fps)	61	57	**82**
Ghost Recon Wildlands (Avg fps)	41	36	**63**
Middle Earth: Shadow of War (Avg fps)	78	75	**96**
3DMark Fire Strike (Index)	11,163	10,207	**15,237**
Price to Performance (Index)	4.88	**5.80**	3.96

Best scores are in bold. Our test bed consists of an Asus Crosshair VI Hero, 2x 8GB of Corsair Dominator Platinum, and an Nvidia GeForce GTX 1080. All games were tested at 1080p on the highest graphical profile, with average fps noted.

VERDICT 7

AMD Athlon 240GE

+ **GEE!** Good value for money; low power draw; reasonable integrated graphics.

− **SHUCKS!** Limited PCIe lanes; no turbo boost; Athlon 200GE is better value.

$80, www.amd.com

SPECIFICATIONS

Base/Turbo Clock	3.5GHz
Cores/Threads	2/4
Integrated Graphics	AMD Radeon Vega 3
Lithography	14nm
Cache L3	4MB
Memory Support	64GB DDR4
Memory Channels	2
Max PCIe Lanes	8
TDP	35W

Asus ROG Pugio

A completely customizable pointer with clever case design

AMBIDEXTROUS MICE are often not particularly ambidextrous. Listen up, manufacturers: You can produce a shell that's as symmetrical as you like, but if you only put side buttons on the left, that ain't ambidextrous, buddy. Unless you're suggesting that lefties pull off some kind of implausible claw with their ring and pinkie fingers. So, well done, Asus, for somehow flipping the script and producing the terribly titled Pugio, a mouse that is visually asymmetrical but properly ambidextrous. It achieves the former by liberally slashing the top of the case, putting a purely aesthetic jutting angle below each of the mouse buttons; the latter by, well, including thumb buttons mirrored on each side of the case.

There's also a small triangular trinket box included within a fancy mesh pouch. Flip it open, and the treasures inside include a pair of replacement Omron switches, and a couple of replacement side panels. The latter are easy enough to install, given that the pre-installed edge buttons are magnetically mounted and removed easily enough with a fingernail; you can choose to cover either pair of thumb buttons, or both if you'd prefer to stay focused on the top edge.

On the other hand, while they're refreshingly solder-free, swapping the top switches does require a little screwdriver action to disassemble the case. It's not the first time we've seen this kind of feature—Asus has done it before, in fact, with the ROG Gladius II—but it's still pleasing to have the option of different switch weights right out of the box, and the potential for extra longevity that comes from easily replaced internal components is something you don't often find on a mouse. Let's be realistic, though: At a rated 50 million clicks, even the base switches are likely to outlast the rubbery cyber-patterned side grips, which dip in on each side with a harsh angle that favors the thumb, but equally leaves something of an uncomfortable void on the opposite side.

If you glance at the opposite page, you'll see our review of the ROG Strix Flare keyboard, and if this mouse's name didn't give you all the clues you need that it's in the same family, the lighting will. There's a huge, brash light bar running through and around the mouse's chin, pushing that light both into your eyes and on to your desk. The same LED display maps itself to the palm logo, and there's similar colorful exuberance on the edges of the Alps-switched mouse wheel which, unusually, we actually quite like. All of this can be customized, synchronized, and alphabetized through Asus's Armory drivers, putting it in line with the rest of your Aura Sync-containing gear.

SHELL SHOCK

We've mentioned the side cutouts, but we should also talk about the top shell a little more. Each button is individually molded, which (it's claimed) improves accuracy; we've never particularly found single-piece top shells to reduce accuracy as such, but having separate chunks of plastic for both right and left certainly doesn't lose the Pugio any points. The wheel, slathered in the same patterned rubber as the side panels, is on the right side of sticky, and rolls with a soft notched action. There's a resolution button, but it's been smartly recessed and gloss-coated so as to be only the slightest bit proud of the main body, meaning you can find it when you want it, but won't accidentally mash yourself into low-res mode. Then there's the palm molding, which is far narrower than usual, making the Pugio feel (if you jab your thumb out to the side) far slimmer than it really is—and it's already a slender thing.

In all, we love the Pugio. It's high on the list of slimline gaming mice, and its customization options—and true ambidextrous design—mean it'll suit just about any hand. Yes, it's expensive, and it has a stupid name, but it's part of a surprisingly exclusive club. **–ALEX COX**

VERDICT 9

Asus ROG Pugio

+ **HUGIO** Flexible design; switchable switches.

− **EWGIO** Sensor tops out at 7,200 dpi; little ring finger support.

$90, www.asus.com

SPECIFICATIONS

Sensor	Optical
Sensitivity	7,200 dpi
Sensor Model	Unknown
Polling Rate	1,000Hz
Programmable Buttons	Yes
LEDs	RGB
Cable Length	6 feet
Weight	4.3oz

Asus ROG Strix Flare

Flare with a fair share of flair

THERE ARE TWO WAYS to look at RGB illumination, and each carries equal weight. One tranche of humanity looks at all the pretty lights, the glowing, and the rainbows, and thinks, "This is what my computing hardware needs." The others peer derisively at colorful gear, and wish it were grayer. Perhaps they even yearn for the return of the tobacco-stained beige of yesteryear. Neither group is correct. RGB done wrong can be distracting, and leave your PC looking cheap and cheesy, and there is such a thing as too little, as Asus' ROG Strix Flare oppositely proves.

Editors tend not to like it when we talk about RGB devices with the LEDs off, particularly before discussing the lights themselves, so let's make this quick: Whack the light button on the ROG Strix Flare to drop everything to zero, and it all but dies. It turns into a hollowed-out husk of a keyboard, a black and gray void of sadness. Start turning up the intensity again, and it's party time, whether you like it or not. Two massive bars spit the lurid illumination on to your desk on either side, the white base below the keys reflects the waves of light back into your face; there's even a clear ROG logo cut-out that lights up, and a replacement Perspex chunk in the box, so you can etch your own. It's ludicrous, even given the company it keeps. Is the next step replacing that top shell (plastic, here, rather than the increasingly common aluminum) with a translucent LED matrix so bright you can't see the keys at all?

Facetious RGB rant over, for now, let's give this a fair shake. It's certainly a feature-packed keyboard, with pulled-out membrane media keys, that aforementioned lighting intensity button, and a one-press Windows key lock for intense moments. There's a moderately scratchy but wonderfully tactile and wide volume roller, and USB pass-through to cut down on awkward desk arrangements—which also means a hefty braided cable welded to the back. The keys are adorned with Asus's always slightly jarring '90s cyber typeface, though its thick font weight (coupled with clear-based Cherry MX Red switches) means so much light bleeds through that you're not going miss which key you're hitting. Reds aren't your only choice—you could opt for MX Brown, MX Blue, or MX Black if you're feeling very frisky—but the low-resistance, low-noise end of Cherry's line feels pretty good in this context, giving the wide caps a fast feel and a high actuation point, with a high-pitched clatter that sounds good enough and doesn't offend sensitive ears. It's not our favorite, but it's highly decent.

FLARE COMMENT

The whole package is well constructed and well designed. The Strix Flare's plastic top plate isn't necessarily a detriment, given its clean lines—there's a very subtle texture change slashing off the bottom-right corner in line with the edge of the Perspex cut-out, which is the sort of delicate touch you might not expect. Underneath are three massive rubbery feet, which keep this stuck to your desk, and a pair of risers with similarly chunky construction; in front is a "soft touch" (basically just silicon-coated plastic) wrist rest, which continues the textured accent. At the PC end, Asus's reliable and option-packed Armory II driver does the business of customizing lighting (including lining it up with the rest of your Asus gear via Aura Sync), recording macros, tracking your typing statistics, and throwing everything to the on-board memory for later.

Really, it's all very pleasant. It might even convert the odd leather-patched IBM Model M stalwart to RGB, it's so pretty. But with an MSRP of $199, they're going to really have to want to leap to this very specific outcropping of the light side, particularly when there's an absolute raft of cheaper, just-as-cool RGB mechanical keyboards sitting in the price bracket below it. If you can find it cheaper, though? Go for it. **–ALEX COX**

VERDICT
7

Asus ROG Strix Flare

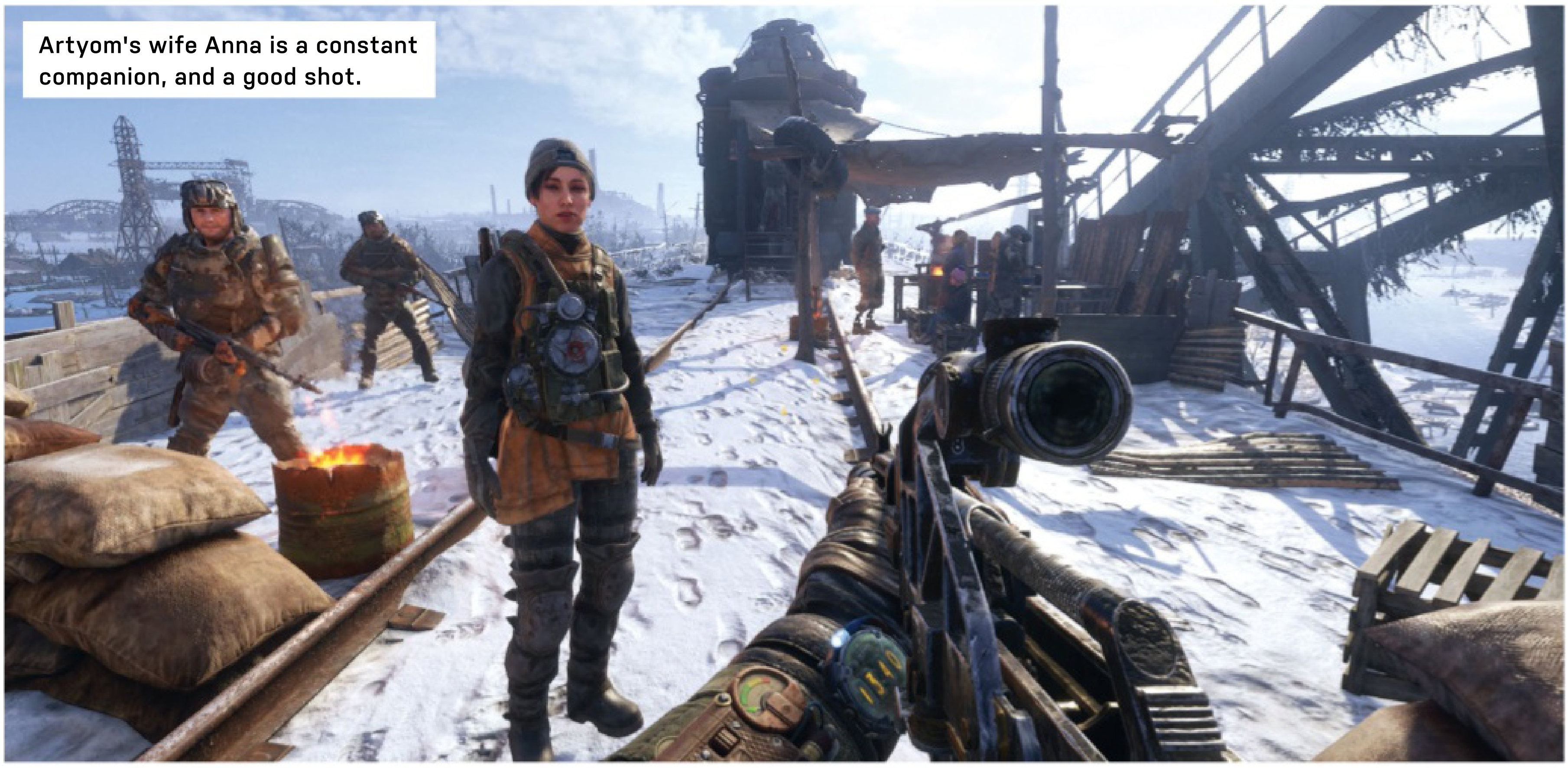
BRIGHT All-over highly customizable RGB; well-placed media controls; plentiful macro options.

FRIGHT Very expensive; slightly sad wrist rest; plastic upper shell.

$199, www.asus.com

SPECIFICATIONS

Switch Type	Cherry MX Red
Form Factor	Full-size
Media Keys	Yes
Macro Keys	Configurable
LEDs	Full per-key RGB
N-Key Rollover	Yes, with anti-ghosting
Pass-Through	USB
Dimensions	17.9 x 6.1 x 1.2 inches
Warranty	Two years



Artyom's wife Anna is a constant companion, and a good shot.

Wildlife asks to be shot.

Corpses beg to be looted.

Faces are very expressive.

Metro Exodus

The year 2035 isn't that far away

WHILE FAR CRY NEW DAWN (opposite) shows the aftermath of an atomic bomb as a sunny land covered in flowers, *Metro* covers it in ice, mutants, and serious men with guns who don't whoop like sports fans when they kill you.

This different approach leads to a very different game. While *Far Cry* is a gleeful slog across an open world, *Metro* keeps things more linear. It's always sunny in Montana, while in Russia fog and blizzards block the view, and underground tunnels necessitate the use of a flashlight or oil lamp. There's also a different amount of detail on offer, even if it means you'll need more GPU grunt to get the most out of it.

Metro's look is one of cold dark metal, of floors you don't want to look at for fear you're standing on bones, and of boots you don't want to remove in case you get frostbite. The trademark gas mask, wiped clean with a grubby hand and pockmarked with cracks and chips, repaired with tape, is as much the game's interface as the sparse HUD, which fades away when it thinks you don't need it. This is fortuitous, as the game's destroyed beauty really is magnificent.

It's a game about a journey as much as it is about shooting men in improvised armor and gas masks. Literally on rails, your base is a train from which you strike out into the wilderness. It's an illusion of freedom and a break from the previous *Metro* games, which stuck to the underside of Moscow. It's not entirely successful, as it robs the game of much of its claustrophobia and *Doom 3*-like feeling of facing monsters in the dark—although there are sections where this is still the case. By recalling many characters to the train while it moves between mission areas, a sense of togetherness emerges that wasn't present among The Order back in Moscow. The hopeless have found hope, and as time progresses, something not unlike family life begins to take hold.

It's all rather lovely. And as you snuggle with your wife in your bunk, first-person shooting can seem a world away. It's not—it always comes back to clicking on bad guys' heads, and combat is still a desperate fight against constrained ammunition as much as it is against the remnants of humanity. Light survival elements—constantly being on the lookout for air filters, for example—add a degree of annoyance, mitigated by a new Reader difficulty that allows you to follow the story without worrying too much about combat. The improvised weapons can be modified with whatever attachments you find on corpses, and you can build up an arsenal that can destroy all comers.

Metro's evolution has been thoughtful and considered, the changes brought in for the good of the series rather than for their own sake. The fact a combat-heavy game offers so many chances to avoid killing, to pass by unseen, or to accept an enemy's surrender tells us much about developers wrestling with the idea of games as simulators of all humanity rather than just our worst impulses, and trying to show a spark of light in a cold, dark, empty world. **–IAN EVENDEN**

VERDICT 8

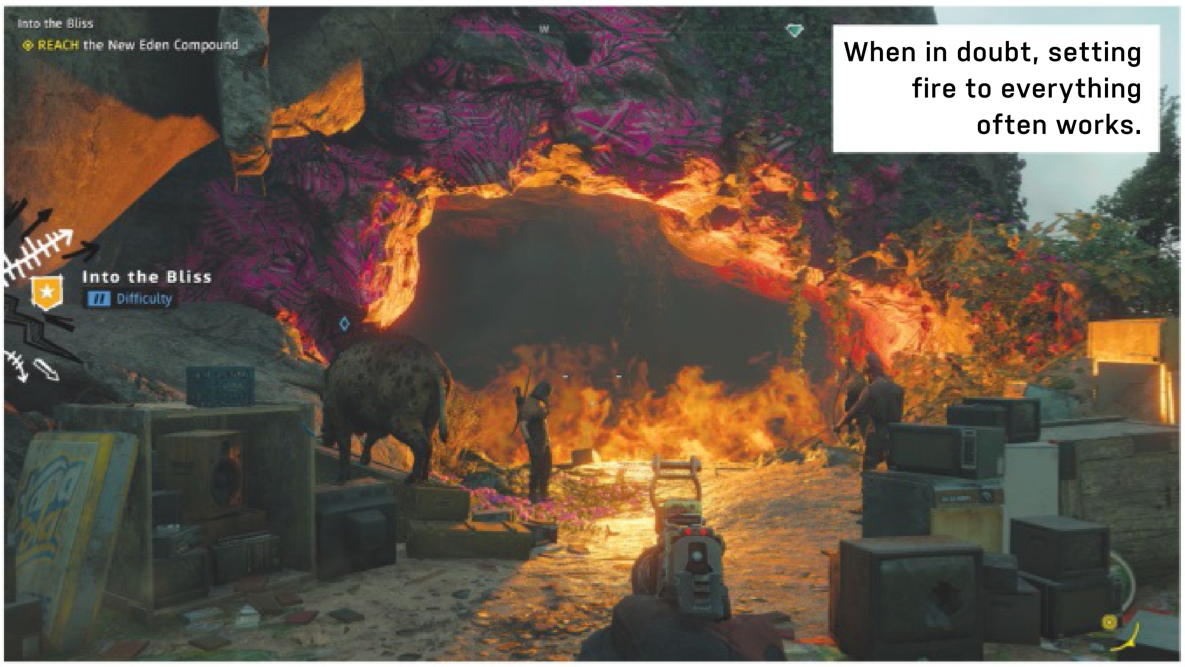
Metro Exodus

+ UNDERGROUND Great looks; compelling storyline; well-explored characters.

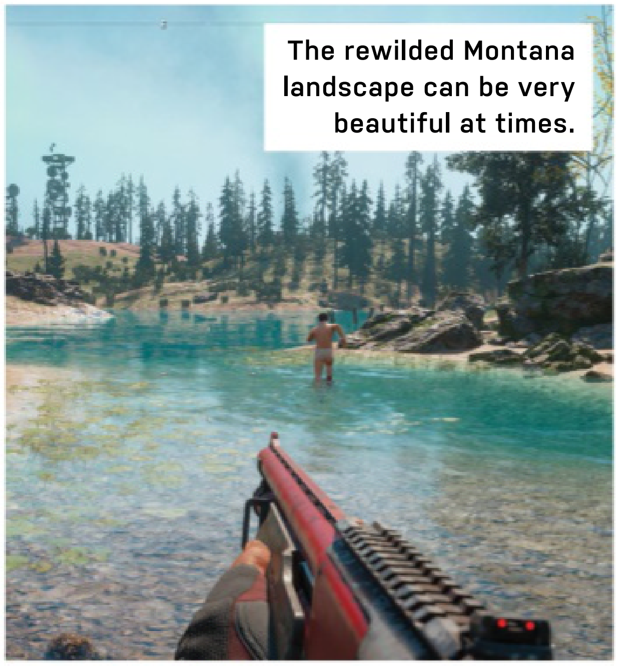
− OVERGROUND Wobbly voice acting; high system requirements; easy to get lost.

RECOMMENDED SPECS i7-4770K or better; 8GB RAM; GTX 1070/RTX 2060/RX Vega 56.

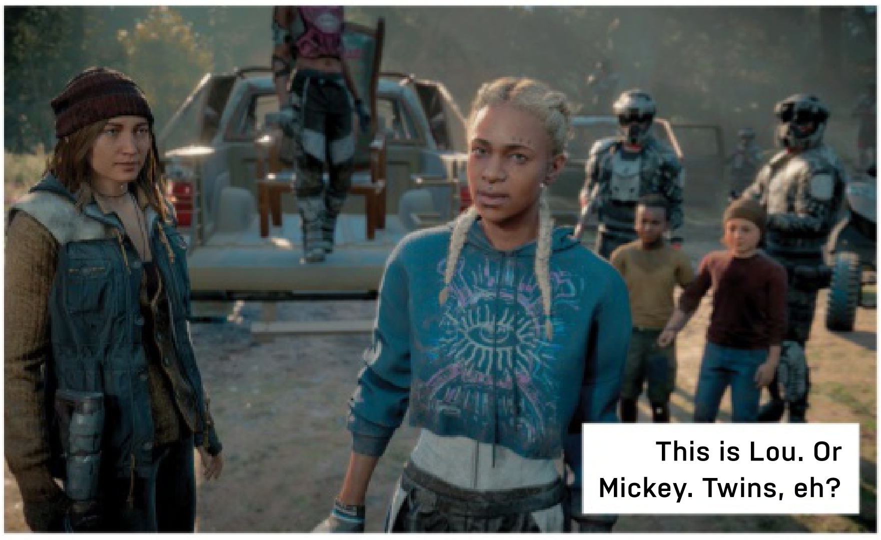
$60, www.metrothegame.com, ESRB: M



When in doubt, setting fire to everything often works.



The rewilded Montana landscape can be very beautiful at times.



This is Lou. Or Mickey. Twins, eh?

Look at this absolute unit.

Far Cry New Dawn

The big bang theory

FAR CRY 5, if you made a certain set of decisions, ended with a nuclear explosion. Under other circumstances, this would seem to be quite final, but Ubisoft has used it to kickstart its next free-roaming adventure. Don't expect a clean slate, however: Things haven't changed much.

We're still in Montana, imagined as a land where the sun always shines, it's permanently spring, and pink flowers carpet the ground. New antagonists the Highwaymen—murderous sportswear enthusiasts led by the latest in the series's run of charismatic psychopaths—are fond of pink, too, spraypainting it wherever they go. It makes a nice change from *Fallout* brown. Couple this with the very reasonable system specs, and it's a game that looks beautiful on even average PCs.

But while the map is reused and the general structure of the game familiar, there's plenty of new stuff here, as Ubisoft plays with the *Far Cry* template ever so slightly. So, there are still outposts to capture, but this time you can abandon them, so they fill up with bad guys again, and you can recapture them. Enemies and weapons now have ranks, so capturing an outpost full of level-two enemies means upgrading your level-one rifle, unless you want a hard slog. Best of all, the notoriety system that led to increasingly tough troops hunting you in *FC5,* ending with unskippable capture-and-escape events, is gone, with twin psychos Mickey and Lou not bothering you too much as you smash your way through their apparently infinite gang members.

Expeditions, which take you out of Hope County on hunts for resources, spice the scenery up a bit as well as introducing a wave-defense mechanic as you wait for your extraction helicopter, the case of loot you're holding broadcasting a signal that brings bad guys in from miles around. Similar, but smaller in scale, are the loot drops that see a crate parachuted in near your location. Highwaymen scramble to get there before you, and you have to kill them before getting your prize of resources and ethanol for your base.

Yes, also new is base-upgrading. The settlement of Prosperity sits near the bottom of the map, and as you rescue guns for hire (you're limited to one active at a time now, but they have more personality) and unlock upgrades, it's ethanol that dictates the pace at which it develops. You can find it being driven around by Highwaymen, which makes for a desperate chase as you race to get your highly explosive cargo back to base before some fool in a bike helmet puts a rocket into it. The skill tree for your character has been streamlined, and the prepper stash treasure hunts that supply many of the perk points you need to improve your skills have been simplified.

The new is balanced by the old in *New Dawn,* and if *Far Cry 5* left you cold, don't rely on this to reignite your interest. But anyone looking for more Hope County action, especially if you're wondering what happened to those New Eden types, should pack a bag for post-apocalyptic Montana immediately. **–IAN EVENDEN**

VERDICT

7

Far Cry New Dawn

⊞ **KABOOMED** A newly streamlined experience in a more interesting world.

⊟ **DOOMED** Same map; familiar ideas; repeated outposts.

RECOMMENDED SPECS i7-4790/Ryzen 5 1600; 8GB RAM; GTX 970/R9 290X, or better.

$40, http://far-cry.ubisoft.com, ESRB: M

LAB NOTES

CHRISTIAN GUYTON, STAFF WRITER

Read on Arrival

This fresh-faced freelancer is ready for his own desk

CAN YOU TELL I'M EXCITED? I've arrived at *Maximum PC* hot on the heels of departing deputy editor Zak Storey, eager to make the team whole again. I'm pleased to say I've been welcomed with open arms and open wallets—we sure do play with some expensive tech. I'm a relative newcomer to the PC-building business; I've toyed with it in the past, but never quite had the funds or expertise to make it really work. Sitting at my own desk—that's a nice feeling—in the *Maximum PC* office, it wasn't long before big boss Alan had me working on new builds, mag-tip screwdriver in hand.

I'm a gamer through and through, excited to be prattling on about games and the beefiest possible machines to run them on. At any given moment, you can find me wearing a bulky headset and muttering expletives as I die for the hundredth time in *Apex Legends*. Except when I'm writing. Getting used to producing content on a Mac has been a bit of an adventure (read: a nightmare), but I'm settled in, leather jacket already on the back of my office chair to greet me each morning.

Apex Legends' **ever-closing ring of death haunts Christian's dreams.**

I moved halfway across the country for this job, away from family, friends, and freelancing, but I feel like it's going to be the best move I've ever made. Gone are the days of scrounging for one-off freelance projects on topics I have zero interest in (medieval architectural restoration? Eh, it paid well), replaced by research sessions that have seen me on the edge of my seat, reading online articles and old back issues well past the end of my actual work hours. I'm looking forward to the future; I hope you are, too.

ALAN DEXTER

Executive Editor

My main test machine has been throttling back. Its Core i7-7700K is a hot chip, but I feared that the cooler wasn't seated properly (cable ties were involved, so this wasn't a ridiculous idea). Moving to a completely new cooler wasn't exactly straightforward, but after a few sliced fingers and choice words, I managed to switch to the glorious Cooler Master MasterAir MA610p. The only problem being that the old flakiness was still there. A dive into the BIOS revealed that the default CPU voltage was set too high at 1.3V, and this was the cause of the overheating. Dropping it to 1.2V solved the problem, with the added benefit that we now have a quieter cooler and a much happier machine.

JARRED WALTON

Senior Editor

The biggest announcement of GDC 2019 was probably the Stadia game streaming service. Google wants to make Stadia the Netflix for gaming, or something like it. It's more like a console rather than part of the PC gaming ecosystem, as games will need to be explicitly ported to the platform. The back-end hardware is a decent PC, with an Intel CPU, and an AMD Vega 56-class GPU, potentially capable of 4K 60fps streaming. Unfortunately, even at 1080p60, input latency was present in the demo I tried. I died five times in the opening level of *Doom* before I was able to adjust to the increased latency. Hopefully the final product will fare better.

Editors' Picks:
Digital Discoveries

Joanna Nelius and Bo Moore reveal the latest games that promise to take up far too much of their time

THE SIMS 4 STRANGERVILLE

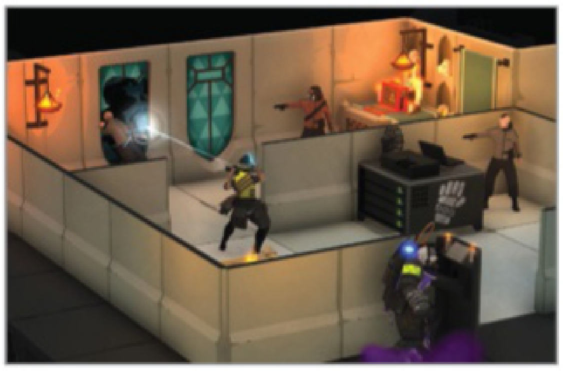
I've spent some time with *The Sims 4 Strangerville* since it was released back in February, and it is by far my favorite game pack. Who doesn't love an extraterrestrial-themed government conspiracy theory? Your sim is at the heart of an investigation into the townsfolks' erratic behavior. Military personnel won't talk. The conspiracists are too eager to talk. It's up to you to discover what is making the people of Strangerville act so… strange.

Anyone can send their pre-existing sims to investigate or create new sims with their own backstories. My sim, Barry Siegmeister, purposefully moved to Strangerville. He saw things he wasn't supposed to when he was in the military, so he made it his life mission to solve the Strangerville Mystery, a new Aspiration you can give to any sim. He purchased some spy bugs and planted them on anyone he could in the town. But listening in on his neighbors' conversations was only the first step. As Barry's journey continued, he discovered the source of everyone's crazy behavior, falling victim to the infectious agent himself. Oh no! What will happen? Tune in next time to find out.
$20, www.ea.com

TACTICAL BREACH WIZARDS

At GDC, I had a chance to try the demo of *Tactical Breach Wizards,* an upcoming game from *Gunpoint* and *Heat Signature* developer Tom Francis. The game is still a long way—probably a year or more—from release, but the early version showed a lot of promise. You play as a team of rogue wizards, but instead of robes and wands, they are garbed in tactical assault gear. The Riot Priest swings an incense burner from behind a massive riot shield, while the Witch Cop dresses like a standard police officer (though with a witch hat, of course), and can fire both her service weapon and a chain lightning ability.

The game plays like *XCOM,* but with you breaching your way through enemy-filled rooms along the same lines as *Hotline Miami.* And like the recent strategy *Into the Breach,* you can rewind your actions in order to try different moves and see what works best. Unlike *Into the Breach,* Francis says he doesn't want the game to be too difficult—instead, it's meant to be a narrative game with a story to tell, with added difficulty in the form of optional challenges in each mission. It's still a long way from release, but I already can't wait.
TBD, https://store.steampowered.com



GEEK TESTED & APPROVED

Roku Express

SOMETIMES IT'S BEST to just go simple. Roku has been knocking about in the media streaming market for a while, providing nifty little boxes that turn any screen into a stream machine. The Roku Express is the company's cheapest offering, a diminutive module that perches beneath your TV or monitor. Unlike Google and Amazon's products, the Roku has an HDMI cable with a sensible length, so no dangling awkwardly behind the TV like a Chromecast. The Express is controlled with a compact remote—or, much more efficiently, the Roku app. It's standard stuff, but it does the job.

What makes the Roku interesting is its approach to programming. All the usual suspects are here, of course: YouTube, Netflix, Amazon Prime, and others, as well as the Roku TV channel, an ad-supported free service showing a variety of movies and TV shows. But the Roku is an open-platform device; anyone can access the software development kit for free, and create channels using Roku's proprietary BrightScript language. That sounds intimidating, but it's essentially the same as JavaScript.

This means that there is a staggering number of channels available. Don't get us wrong; with a fully open approach like this, there's a lot of utter crap in there. Exploring the channel list is an oddly fascinating exercise, though. Dedicated channels for slasher flicks? Sure. A whole host of gaming-related channels, covering everything from *PUBG* to *Minecraft?* Done. There's some truly bonkers stuff on there, and we had fun trawling through the weirder offerings. **–CG**
$30, www.roku.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON…

> Thunderbolt 3 vs. USB-C
> Drive Disappearance
> Deleting Duplicates

Confusion of Standards

I've had a hell of a time connecting my Dell laptop with a Thunderbolt 3 port to a new Dell U2719DC display via USB-C. What I assumed I was getting was in theory awesome—one USB-C cable from the Thunderbolt 3 port on my laptop to the USB-C connector on my monitor, which would charge the laptop, activate the USB ports on the monitor, and light up my two external displays with a DisplayPort daisy chain.

This was a disaster of weeks of learning what is really going on with this newfangled USB-C cable. Since my Dell display is USB-C, not Thunderbolt 3, my connection from laptop to monitor was running at USB-C speeds not Thunderbolt 3. That means that daisy-chaining my second display via "multi-stream transport" (MST) was going to happen only at 1080p. But if I connect my laptop via Thunderbolt 3 connector to DisplayPort with a USB-C to DP cable, USB-C operates in "Alt-Mode DisplayPort," so MST can support the 1680x1440 resolution of both displays. I lose charging and USB connectivity over the USB-C cable, so that the connection from laptop to monitor is essentially just a DisplayPort connection.

All very complicated. It's nice to have a single cable standard, but it's confusing to have so many protocols run over USB-C, as your results vary depending on what's implemented in your hardware. **–Marc Mackey**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: While the dream of what you want is indeed awesome, the industry doesn't quite have everything in place yet. The confusion is down to Thunderbolt 3 being a superset of USB 3.1, so while it's physically compatible, Thunderbolt 3 operates at 40Gb/s as opposed to USB's 10Gb/s. This gives more bandwidth to drive panels, charge devices, etc., but only if both devices are Thunderbolt 3, which is where your panel falls down. The good news is that the future looks good as far as sorting this mess out, as Intel has promised to open up Thunderbolt 3 so that it'll get wider acceptance. It's certainly something we'll look to cover in a future issue.

Windows Media Center

As Windows 7, which I use on my desktop for recording from a Ceton card with a cable card installed, is due to sunset, I was hoping for an article addressing Windows Media Center, specifically regarding its cable card abilities. What is a good replacement, as I like to record so that I can watch offline, and other streaming services don't work? I don't care about copy protected channels, as most of my watching on WMC allows copying between devices.

WMC just works, and I would like that in a new setup. What will happen in my setup on Jan 15, 2020? Fade away or abruptly stop working? **–Craig**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: We have written a few features on replacements for Windows Media Center, although nothing that quite covers what you need. The problem is down to copy protection: You may not be interested in such things, but the major content services are, and they don't like the idea of subscribers sharing content (even if it's just with other machines in your own house).

There is one bit of good news: When Windows 7 goes end of life, it won't suddenly stop working. Nothing will happen, apart from maybe one final push of patches to try to shore it up for the future. So, you have a solution that currently works, and will continue to work if you protect the PC from outside threats. Keep using it.

Missing Drive

I just built my third PC, and I used your "Back to the Basics Build Guide" in the October 2018 issue. However, now that Windows 10 is fully installed and updated, I can see my HDD in Disk Management, but it is not visible in my "This PC" list. Within Disk Management, the SSD is Disk 0, and the HDD is Disk 1. Disk 1 is "online," but its 465.25 GB is "Unallocated." During the Windows install, after selecting "Custom Install" and choosing my SSD as my primary drive, I wasn't presented with an error, so I figured

↘ submit your questions to: comments@maximumpc.com everything was good to go. I've tried initializing the drive, and assigning a drive letter, but neither option is available. I am at a loss. After installing my drives into the case, I used two separate power cables from the PSU; each cable has two connectors. I hope the way I hooked them is correct. **–Tom Brack**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: Fear not, Tom, we've seen plenty of problems like this over the years, and there's usually a way to fix it. The fact that the drive is showing up in Disk Management suggests that it isn't a problem with how you've connected the drive, but a driver or software problem. When you say you can't initialize or assign a letter to the drive, we'll assume those options are grayed out in the Disk Management tool, so instead we'll turn to the command prompt.

Right-click the Windows "Start" button, and select "Command Prompt (Admin)" or "Windows PowerShell (Admin)" from the pop-up menu. Type "diskpart" at the prompt, followed by "list volume". You should find your unallocated drive listed here; make a note of its volume number. Next type "select volume X" where X is its number, then "delete volume". You should now be able to create a new volume for the drive using Disk Management.

If this doesn't solve your problem, try reinstalling the driver. Right-click "Start" again, then select "Device Manager," locate your drive under "Disk drives," right-click it, and select "Uninstall device" from the drop-down. Confirm your uninstall, and once it has been removed, select "Scan for hardware changes" from the "Action" menu. If successful, you should be able to create a volume in Disk Management once again.

[NOW ONLINE]

ALL YOU NEED TO KNOW TO RUN THE DIVISION 2 AT HIGH FRAME RATES

The past few months have been a great time for major game releases. From the surprise launch and excellent experience of *Apex Legends* to the tragic singing (not really) of *Anthem*, with post-apoc *Metro Exodus* journeys and more, we've had a lot going on. We tested *The Division 2* beta in February, and with the final game in hand, it's time for the full update. The good news is that performance has improved by about 15 percent. It could improve further over time, but given the impressive level of detail for the DC environments and other areas, not to mention the mature game engine, we don't expect too many changes. Also, note that *The Division 2* is an AMD promo game, which means along with the Ryzen/Radeon splash logo when you launch it, it's likely to be tuned to run best on AMD graphics hardware. As for CPUs, performance is fine as long as you have a six-core or better processor....

Read the full article: https://bit.ly/2TfOtfD

Duplicate Finder

I've just read "Optimize Windows" in your March 2019 issue. Much of the advice was helpful, but you didn't address cleaning out similar or duplicate images. This surprised me, as such images can rapidly pile up. The best software I've found for identifying similar or duplicate images is VisiPics, but it did not identify all such images I set up as a test. An old shareware program called Unique Filer worked fairly well, but it is no longer available. Programs that identify duplicate files do not show images to let the user decide which image to delete. What would you recommend? **–F. Ewing**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: There's a number of tools that do this, but the depth to which you go depends on how you organize your files. If you're looking for a basic way of finding duplicates, CCleaner's File Finder tool can highlight them. Image duplication can be trickier, so a tool like Duplicate Photos Fixer Pro (www.duplicatephotosfixer.com) could be useful, and is available as a trial version as well. Or, Duplicate Image Remover (www.manyprog.com) is free. If any readers use a specific tool, please let us know.

Optimize This

The lead feature in the "Optimize Windows" issue has nothing about optimizing Windows. The only thing the article wrote about was cleaning up your drive. The closest it came to living up to its title was an excerpt on killing programs that start automatically, but concluded with this disclaimer: "By all means experiment..." Then why do I need your publication? It continues "...bear in mind that we can't be held responsible if you chop something critical, and that its results can often be as negative as they are positive." So don't trust anything you say, and the results if I do could be a disaster, or if I am lucky, positive. **–Jacob Simpson**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: Windows is an operating system. As with any OS, its core functionality is to manage your hardware and software. In the case of Windows, a fundamental part of this is the handling of the apps, utilities, and tools you have installed. Install enough without any thought, and your machine slows down significantly. Sorting these out, changing how and when they load, and uninstalling tools you don't use has a significant impact on performance. In fact, doing so generally has a greater impact on Windows performance than any other tweaks and tricks. Which is why we focused on that, although we also covered how to optimize the Registry, clean up your desktop for faster working, set up rules for storing files in a more organized manner, and more. What were you looking for in an optimization feature? As for the disclaimer, there is always a risk when uninstalling anything that something you usually do or rely on stops working, and it would be remiss of us to not point this out in an article that talks about removing software.

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THE BUILDS

BUDGET

MID-RANGE

INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$55
PSU	450W Corsair VS450 80+ White **NEW**	$40
Mobo	ASRock B450M R4.0 AM4 **NEW**	$60
CPU	AMD Ryzen 5 2600	$165
GPU	Gigabyte GeForce GTX 1660 6GB **NEW**	$220
RAM	8GB (2x 4GB) Patriot Viper 4 @ 3,000MT/s	$58
SSD	120GB ADATA Ultimate SU650 2.5-inch SSD	$25
HDD	1TB Seagate Constellation ES 3.5-inch HDD **NEW**	$35
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit	$15

Approximate Price: $673

BUDGET POWER SUPPLIES were a rare commodity this month, forcing us to trade out our EVGA model for Corsair's 450W offering—prices seem to have jumped up among the lower-wattage PSUs. We also opted to upgrade the graphics card, taking us out of 3GB territory and toward 6GB (check out "Upgrade of the Month"). Gigabyte's new GTX 1660 and another upgrade to the ASRock B450M motherboard (compared to last month's AB350M) give this build a little more punch for 1080p gaming. Despite this, we've only raised the overall price by a paltry four dollars, thanks to minor savings across the board. These add up: a few dollars from the CPU's price drop, a few from the change of motherboard, a solitary one from Ubuntu, for some indiscernible reason. Lastly, we swapped out the Western Digital HDD for a comparable Seagate offering, as WD's prices seemed to have leapt this month.

INGREDIENTS

PART		PRICE
Case	Fractal Design Meshify C	$90
PSU	550W Corsair CX550M 80+ Bronze **NEW**	$60
Mobo	Asus ROG Strix B450-F Gaming	$135
CPU	AMD Ryzen 7 2700	$250
Cooler	Corsair Hydro H100i Pro 240mm RGB AIO	$110
GPU	Zotac Gaming GeForce RTX 2060 6GB **NEW**	$350
RAM	16GB (2x 8GB) G.Skill Aegis @ 3,000MT/s	$90
SSD	250GB Samsung 970 Evo Plus M.2 PCIe SSD **NEW**	$88
HDD	1TB Seagate Constellation ES 3.5-inch HDD **NEW**	$35
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,308

OUR MID-RANGE BUILD is parroting the budget rig a little this month. Rising power supply prices again forced us to swap out the Corsair CX500M for a CX550M in order to keep the overall cost from climbing, and copying the budget build's shift to a Seagate Constellation HDD was a sensible move to make a small saving. That's not all that's going on here, though: We also upgraded the SSD from Samsung's 970 Evo to the 970 Evo Plus, saving us $8, and netting a slightly faster drive for the build. Another change made in the name of price conservation was the switch to a Zotac graphics card, away from EVGA's RTX 2060 model. The previous GPU had become slightly pricier, so Zotac's version of the RTX 2060 enabled us to retain the same graphical clout without sacrificing money. And, as always, a copy of Windows remains an unchanging feature of this build.

TURBO

UPGRADE OF THE MONTH

GIGABYTE GEFORCE GTX 1660 6GB

GPU prices are forever in flux, and trying to upgrade on a relatively low budget can be a real challenge. The new GTX 1660 is exactly what we needed, though—specs-wise, it might only be a modest upgrade from the GTX 1060, but on average, you're looking at a 20 percent improvement. We went with Gigabyte's version of the card, although Zotac, Asus, and MSI all offer comparable models—be sure to shop around if you're looking for a 1660. The Gigabyte card is a two-fan affair, but still very compact, easily fitting into smaller cases. With 6GB of GDDR5, and overclocking very much on the table, it's hard not to recommend the 1660 for budget builds. **$220, www.gigabyte.com**

THERE WASN'T MUCH TO CHANGE here. Last month's GPU upgrade held steady with very little price variation, the 2080 still pumping out top-notch visuals when paired with the Threadripper 2950X CPU. In a pleasant surprise, this Threadripper has dropped $70, which sees the build drop hugely in price. It's strange to see a high-end CPU released only half a year ago already on sale, but we're not complaining. The scarcity of Threadripper-compatible motherboards and coolers meant there was little we felt comfortable swapping out; the X399 Phantom Gaming 6 from ASRock remains the best value mobo for these CPUs. We did mix it up with the cooler, however, going with Be Quiet!'s Threadripper-only dual-fan offering for only $10 more. This will keep the CPU cool without having to resort to a costly liquid-cooler.

Elsewhere, we traded out the RAM—but only very slightly. Sticking with Corsair's Vengeance range, we've swapped LED for RGB, but stuck with a quad 8GB kit. This ran us an extra couple of dollars over last month's RAM cost, but our previous choice had risen in price, making this the better option. Be sure to check compatibility between the motherboard and RAM when using Threadripper builds, as your options can be a bit limited. Nothing else really needed changing, although it was good to see the Corsair power supply drop by 10 dollars, justifying our cooler upgrade.

For more of our component recommendations,
visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART			PRICE
Case	NZXT H700i		$180
PSU	750W Corsair RM750X 80+ Gold		$110
Mobo	ASRock X399 Phantom Gaming 6		$240
CPU	AMD Threadripper 2950X		$800
Cooler	Be Quiet! Dark Rock Pro TR4	NEW	$90
GPU	Asus Turbo GeForce RTX 2080		$710
RAM	32GB (4x 8GB) Corsair Vengeance RGB @ 3,000MT/s	NEW	$250
SSD	512GB Samsung 970 Pro M.2 NVMe		$168
HDD	2x 2TB Seagate BarraCuda ST2000DM006		$120
OS	Windows 10 Home 64-bit OEM		$100
Approximate Price:			**$2,768**

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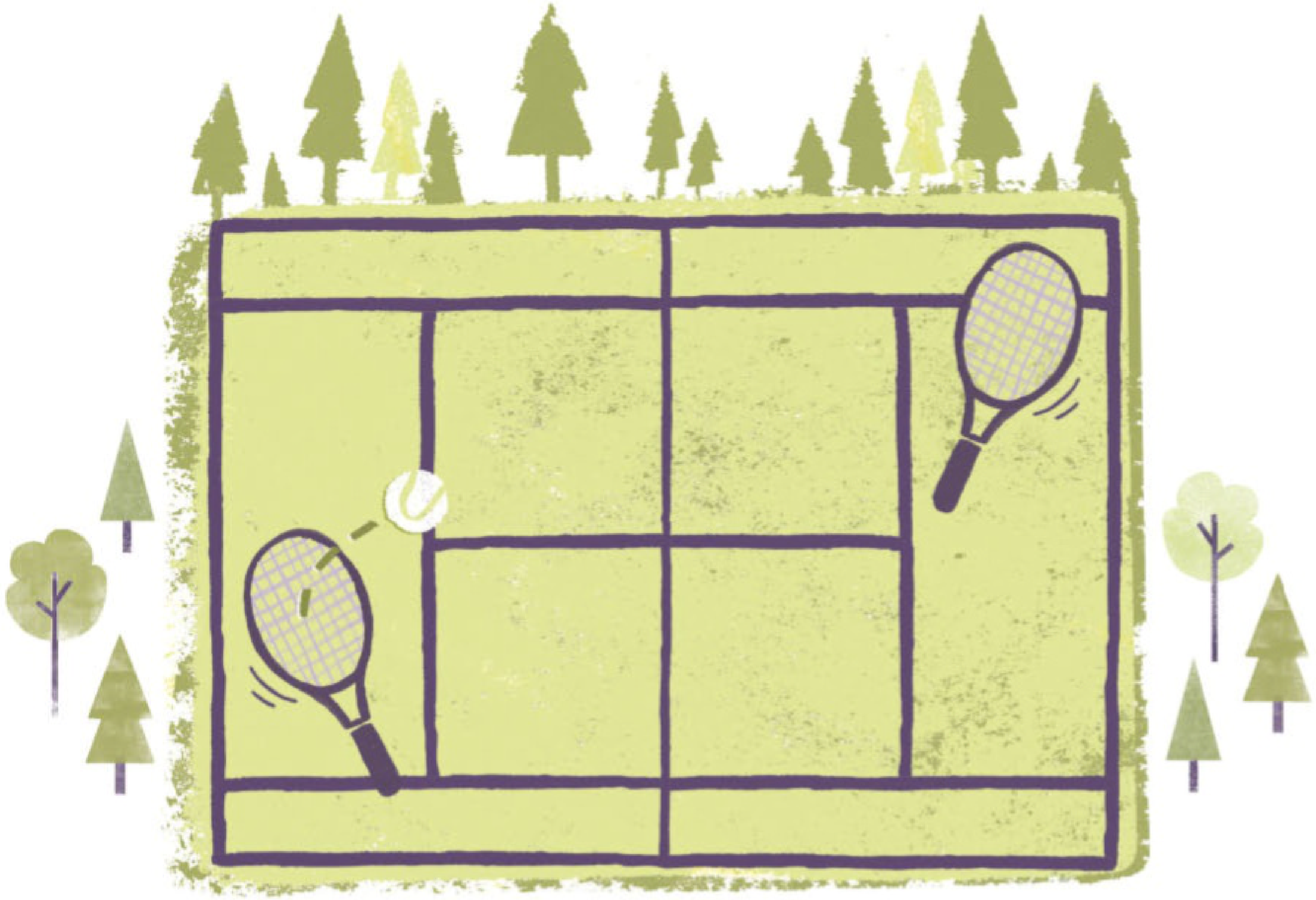

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